Substation Design Manual

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This material is made available on the basis that it may be necessary for a Registered Professional Engineer of Queensland (RPEQ) to undertake or oversee the engineering services to meet statutory obligations.

Revision History

Version	Description of Change	Approval Date	Revised By
1	Initial version	25/03/2013	
Draft 2a	Content revised and additional content added, including Project Delivery, Documentation. Control and Switchgear Building, Primary Plant (Layout, Transformers, Switchboards), Secondary Systems (CB Fail, U/F, Metering, LV cabling), Period Contract Plant and Relays, Software Parameter Tables, Design Modules, and Drawing Lists. Some Civil content removed and now included in Civil Standard.	11/02/2014	C. Woods

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Ergon Energy Queensland Pty Ltd ABN 11 121 177 802

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1. PURPOSE AND SCOPE

This document is a reference for the Designers of Ergon Energy substations and it covers all aspects of substation design for both Greenfield and Brownfield substation projects to meet the performance expected by Ergon Energy. The manual is applicable for all substation projects regardless of internal/external design delivery mode.

The substation design manual is not intended to replace Asset Management Standards, but rather to act as a reference document that cross-references existing standards and process documentation and plugs any gaps where Asset Management documentation does not exist.

The Ergon Energy design philosophy is to provide substations:

(a) Safe for the public.

(b) Safe for operation and maintenance personnel.

(c) Safe for plant and equipment.

(d) With environmental considerations, and aesthetic quality.

(e) Delivering supply of electricity to its customers, safely, with acceptable levels of quality and reliability.

(f) Satisfying Ergon Energy's minimum standards for transmission, sub-transmission and zone substation design.

(g) Meeting the requirements for future ultimate development.

(h) At the lowest possible cost.

2. RESPONSIBILITIES

The **Group Manager Works Enablement** is the Process Owner responsible for approving this Reference.

The **Manager Substation Design** is the Subject Matter Expert (SME) for the content and shall implement and maintain this Reference.

The **Manager Management Systems** is the Management System Representative and is responsible for the endorsement of this Reference prior to submission for approval.

3. DEFINITIONS, ABBREVIATIONS AND ACRONYMS

AEMO	Australian Energy Market Operator
AFLC	Audio Frequency Load Control
BCD	Binary Coded Decimal
BOM	Bill of Materials
Brownfield Site	An existing energised site
CAD	Computer Aided Design
CBF	Circuit Breaker Fail
CCM	Construction Commenced
CPC	Certificate of Practical Completion
DC	Design Complete
EDMS	Electronic Document Management System

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EMF	Electromagnetic Field
FCA	First Capacity Available
GA	General Arrangement
Greenfield Site	Is a term used to describe undeveloped land in a city or rural area
HV	High Voltage (greater than 1000 V a.c.)
LCF	Local Control Facility
LV	Low Voltage (Exceeding 50 V a.c., but not exceeding 1000 V a.c.)
PCO	Project Close Out
PIA	Project Initiation Advice
PSS	Project Scope Statement
PSR	Protection Setting Request
QECMM	Queensland Electricity Connection and Metering Manual
RPEQ	Registered Professional Engineer Queensland
RTU	Remote Terminal Unit
RWR	Recommended Works Report
SLD	Single Line Diagram
SME	Subject Matter Expert
SPRMP	Simple Project Risk Management Plan
SS	Substation Standards
TCS	Trip Circuit Supervision
WPIA	Works Planning Initiation Advice

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4. REFERENCES

4.1 Ergon Energy Controlled Documents

BS001603F100	Transmittal Note - eLibrary Storage and/or Registration (Form)
ES000901R148	Workplace Signage (Reference)
ES000904R104	EMF Guideline for New Infrastructure (Reference)
ES000905F102	Safety in Design Risk Assessment (Form)
ES000905R104	Safety in Design (Reference)
ES000905R105	Safety in Design “Distribution Design” (Quick Reference Guide)
MN000301R171	Test and Commissioning Manual (Reference)
MP000903R117	Environmental Protection Requirements (Reference)
NA000403R328	Queensland Electricity Connection and Metering Manual (Reference)
NI000201W101	Plan, Schedule, and Resource Design Work (Work Instruction)
NI000401F101	Design Checklist (Form)
NI000401F104	Transmittal Note (Form)
NI000401F112	Drawing Approval Matrix (Form)
NI000401R116	Index for Substation Operations Manual (Reference)
NI000401R117	Substation Controlled Drawings (Reference)
NI000401R118	Substation Controlled Drawings (Quick Reference Guide)
NI000401R122	Substation Construction Manual (Reference)
NI000401W101	Prepare Design Inputs (Work Instruction)
NI000401W103	Produce and Verify Concept Design (Work Instruction)
NI000401W104	Perform Detailed Design Work (Work Instruction)
NI000401W105	Produce Design Outputs (Work Instruction)
NI000401W106	Obtain Project Owner Verification (Work Instruction)
NI000401W107	Issue Final Design Documents (Work Instruction)
NI000402F100	Equipment and Materials Procurement List (Form)
NI000402W100	Initiate Procurement of Equipment and Materials (Work Instruction)
NI001303W100	Complete Post Commissioning Requirements (Work Instruction)
PW000702F100	Simple Project Risk Management Plan (Form)
STMP004	Standard for Communications Equipment Installation (Standard)

4.2 Asset Management Substation Standards

Ergon Energy is transitioning its standards to the new corporate taxonomy. All new standards will be published with the STNW numbering system prefix. Documents published with STNW numbering will supersede the SS- legacy documents.

STNW1169	Network Operational Identification and Naming Standard: Substation, Generation and Communication Equipment
SS-1-1.1 (STNW3000)	Substation Design Standard System

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SS-1-1.2 (STNW3001)	Substation Equipment Identification
SS-1-1.4 (STNW3003)	Substation Design Requirements
SS-1-1.8 (STNW3007)	Substation Standards on Climatic and Seismic Conditions
SS-1-3.1 (STNW3013)	Clearances in Air
SS-1-3.2 (STNW3014)	Busbar Design
SS-1-4.1 (STNW3015)	Primary Plant Ratings
SS-1-4.3 (STNW3017)	Capacitor Banks
SS-1-4.4 (STNW3018)	Cables and Cabling
SS-1-5.1 (STNW3022)	DC Supplies
SS-1-5.2 (STNW3023)	AC Supplies
SS-1-6.1	Civil Works
SS-1-7.1 (STNW3028)	Substation Earthing
SS-1-7.2 (STNW3029)	Safety Earthing
SS-1-7.3 (STNW3030)	Soil Resistivity Testing
SS-1-8.1 (STNW3031)	Substation Surge Protection
SS-1-8.2 (STNW3032)	Substation Lightning Protection
SS-1-8.3 (STNW3033)	Selection of Surge Arresters
SS-1-8.4 (STNW3034)	Insulation Coordination
SS-1-9.1 (STNW3035)	Substation Fire Protection
SS-1-9.2 (STNW3036)	Oil Containment
STNW3037	Standard for Substation Signage
SS-1-9.5 (STNW3039)	Substation Security
STNW3040	Standard for Substation Lighting
SS-1-10.1 (STNW3041)	Audible Noise
SS-2-2.1 (STNW3100)	Protection Standard
SS-2-3.1 (STNW3106)	SCADA Standard Points List
SS-2-3.2 (STNW3107)	SCADA Standard Point Naming
SS-2-3.10	Capacitor Automatic Control
SS-2-3.11	SCADA Points List For ICCP
SS-2-3.12	OLTC AVR Control
SS-2-3.20	SCADA Point List For IGM
SS-2-3.21	SCADA Auto Reclose Implementation
SS-2-4.1 (STNW3114)	Metering
SS-2-4.2	Ripple Control Receiver Internal Program Features – Type RO

4.3 Other References

EEAD-0002	Electronic Drawing Management System Approver Manual
EEAD-0003	Electronic Drawing Management System Author Manual

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EEAD-0004	Electronic Drawing Management System Author Handbook – AutoCAD
EEAD-0005	Electronic Drawing Management System Author Handbook – Microstation
EEAD-0016	Electronic Drawing Management System Archiving & Superseding Guide
EEAD-0060	Electronic Drawing Management System Single Line diagram Operating User Guide

Ergon Energy CAD Standards Manual

Ergon Energy Overhead Construction Manual

Ergon Energy Underground Construction Manual

4.4 Legislation and Standards References

AS 1100	Technical Drawing
AS 1101	Graphical Symbols for General Engineering
AS 1102	Graphical Symbols for Electrotechnical Documentation
AS 1940	Storage and Handling of Flammable and Combustible Liquids
AS 2067	Substations and High Voltage Installations exceeding 1kV AC
AS 2676	Guide to the Installation, Maintenance, Testing and Replacement of Secondary Batteries in Buildings
AS/NZS 3000	Australian/New Zealand Wiring Rules
AS 3883	Computer Graphics – Computer Aided Design (CAD)
AS 4436	Guide for the Selection of Insulators in respect of Polluted Conditions
AS/NZS ISO 9001	Quality Management Systems – Requirements
ENA EG-0	Power System Earthing Guide
IEEE-80	Guide for Safety in AC Substation Grounding

Professional Engineers Act 2002

Queensland Electrical Safety Act 2002

Queensland Electrical Safety Regulation 2013

Queensland Environmental Protection Act 1994

Queensland Work Health and Safety Act 2011

Queensland Work, Health and Safety Regulation 2011

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5. SAFETY LEGISLATION AND POLICIES

5.1 General

Safety is a paramount concern of Ergon Energy and all design and supply of equipment and materials must take into account all safety implications for its construction, maintenance, operations, and ultimate disposal.

Safety considerations and relevant publications are detailed in SS-1-1.4 Substation Design Requirements Section 6.

5.2 Ergon Energy Workplace Health and Safety Policy

Ergon Energy is committed to working in a way which ensures the health and safety of its employees, contractors, customers and members of the public.

To support this commitment, Ergon Energy shall:

- Continually reinforce that working safely is a mandatory condition of employment for all employees and contractors.
- Implement a Health and Safety Management System that not only meets all statutory and industry health and safety requirements, but also aims to achieve best practice.
- Ensure all levels of management demonstrate commitment to and are accountable for community and workplace health and safety.
- Establish and measure occupational health and safety programs to reduce work-related injury and illness.
- Continue to deliver comprehensive safety leadership programs.
- Integrate community and workplace health and safety requirements into all relevant business processes and decisions.
- Consult and involve employees in the development and implementation of workplace health and safety programs that strive for continuous improvement towards zero injuries.
- Develop and implement procedures and work practices which minimise and manage exposure to workplace hazards and risks.
- Ensure all employees and contractors have the information, training and equipment required to competently and safely perform their work.
- Provide and manage the rehabilitation of injured/ill employees.
- Recognise, reward and promote employees who demonstrate positive safety behaviours and take personal responsibility for their safety and those around them.
- Allocate adequate resources to fulfil the aims of this policy.
- Monitor and report compliance with statutory, industry and corporate health and safety requirements.

5.3 Queensland Electrical Safety Legislation

The Qld Electrical Safety Act 2002 provides that an electricity entity has an obligation to ensure that its works:

(a) are electrically safe, and

(b) are operated in a way that is electrically safe

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The Qld Electrical Safety Act 2002 provides that the Designer of electrical equipment or an electrical installation has an obligation to ensure that:

(a) the electrical equipment or installation is designed to be electrically safe, and

(b) if the Designer gives the design to another entity who is to give effect to the design, the design is accompanied by information about the way the electrical or installation must be used and installed to ensure the equipment or installation is electrically safe.

The Qld Electrical Safety Regulation 2013 provides the following requirements that apply for the works of an electricity entity:

(a) the works must be able to perform under the service conditions and the physical environment in which the works operate;

(b) the works must have enough thermal capacity to pass the electrical load for which they are designed, without reduction of electrical or mechanical properties to a level below that at which safe operational performance can be provided;

(c) to the greatest practicable extent, the works must have enough capacity to pass short circuit currents to allow protective devices to operate correctly;

(d) the works must have enough mechanical strength to withstand anticipated mechanical stresses caused by environmental, construction or electrical service conditions;

(e) the works must be:

(i) designed and constructed to restrict unauthorised access by a person to live exposed parts; and

(ii) operated in a way that restricts unauthorised access by a person to live exposed parts;

(f) design, construction, operation and maintenance records necessary for the electrical safety of the works must be kept in an accessible form;

(g) parts of the works whose identity or purpose is not obvious must be clearly identified by labels, and the labels must be updated as soon as possible after any change is made to the works;

(h) electrical equipment intended to form part of the works of an electricity entity must undergo commissioning tests and inspection to verify that the electrical equipment is suitable for service and can be operated safely when initially installed or altered.

5.4 Workplace Health and Safety

5.4.1 Work Health and Safety Act

The Queensland Work Health and Safety Act 2011 provides the framework to protect the health, safety, and welfare of all workers at work, and of all other people who might be affected by the work.

Under the WH&S Act everyone has duties (obligations), and the duties for a person conducting a business or undertaking are defined and involve:

- management or control of workplaces
- management or control of fixtures, fittings or plant at workplaces
- design of plant, substances or structures
- manufacture plant, substances or structures
- Importation of plant, substances or structures
- supply plant, substances or structures
- installation, construction, commissioning plant or structures

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- Officers, workers and other persons also have duties

Designers of plant, structures or substances have a duty:

(a) To Ensure Health and Safety in The Workplace

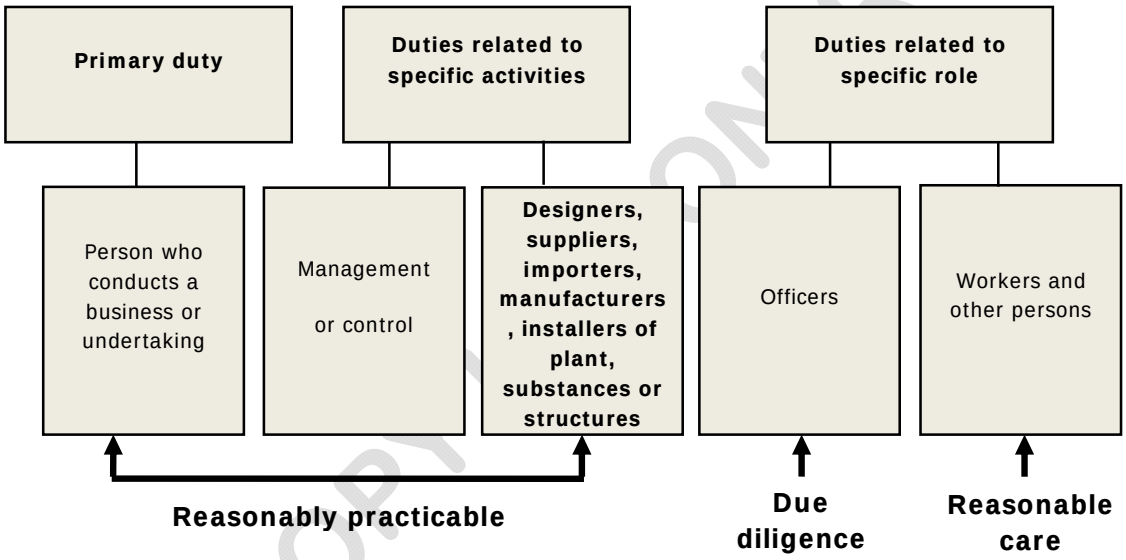
A Designer of a plant, structure or substance that is to be used, or could reasonably be expected to be used, at a workplace must ensure all workplace activity relating to the plant, structure or substance, including its handling or construction, storage, dismantling and disposal is designed to be without risks to health or safety.

(b) To Test

A Designer of the plant, structure or substance must carry out tests and examinations sufficient to ensure that when used for its intended purpose it is safe and without risks to health or safety.

(c) To Provide Information

Information must be made available to those for whom the plant, structure or substance was designed about its intended purpose, test results and any conditions necessary to ensure that it is safe and without risks to health or safety, when used for its intended purpose.



5.4.2 Reasonably Practicable

A Person conducting a business or undertaking must ensure, so far as is reasonably practicable the health and safety of:

- workers (broadly defined) engaged, or caused to be engaged by the person; and
- workers whose activities in carrying out work are influenced or directed by the person; and
- other persons are not put at risk from work carried out as part of the conduct of the business or undertaking

A person conducting a business or undertaking must ensure, so far as is reasonably practicable:

- provision and maintenance of a work environment without risks to health and safety
- provision and maintenance of safe plant and structures
- Provision and maintenance of safe systems of work
- Safe use, handling and storage of plant, structures and substances
- Provision of adequate facilities

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- Provision of information, training, instructions or supervision
- Monitoring of workplace conditions

Reasonably practicable, in relation to a duty to ensure health and safety, means that which is, or was at a particular time, reasonably able to be done in relation to ensuring health and safety, taking into account and weighing up all relevant matters including:

(a) the likelihood of the hazard or the risk concerned occurring; and

(b) the degree of harm that might result from the hazard or the risk; and

(c) what the person concerned knows, or ought reasonably to know, about the hazard or the risk; and

(d) ways of eliminating or minimising the risk; and

(e) the availability and suitability of ways to eliminate or minimise the risk; and

(f) after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

5.4.3 Safety in Design (Risk Management)

Section 17 Management of Risks of the Work Health and Safety Act 2011 states -

"A duty imposed on a person to ensure health and safety requires the person—

(a) to eliminate risks to health and safety, so far as is reasonably practicable; and

(b) if it is not reasonably practicable to eliminate risks to health and safety, to minimise those risks so far as is reasonably practicable."

Safety in Design is defined as the integration of hazard identification and risk assessment and control methods early in the design process to eliminate, and if this is not reasonably practicable, minimise the risk to health and safety throughout the life of the product being designed.

The Designer must document using the Safety in Design Risk Assessment Form any hazards or risks associated with the design, construction, operation, maintenance, and decommission of the structure in the design development phase. These risks must be assessed, and any residual risks assessed as higher than a low risk must be documented in the Simple Project Risk Management Plan. For design works undertaken by an Ergon Energy Designer, the Designer will supply a Simple Project Risk Management Plan (SPRMP) detailing any specific risks or hazards not covered by Ergon Energy's Standard Safe Work Method Statements (SWMS), Standard Work Practices (SWP), or Work Instructions for identified risks or hazards for the construction work. Refer to:

- ES000905R104 Safety in Design Reference
- ES000905R105 Safety in Design "Distribution Design" Quick Reference Guide
- ES000905F102 Safety in Design Risk Assessment Form
- PW000702F100 Simple Project Risk Management Plan

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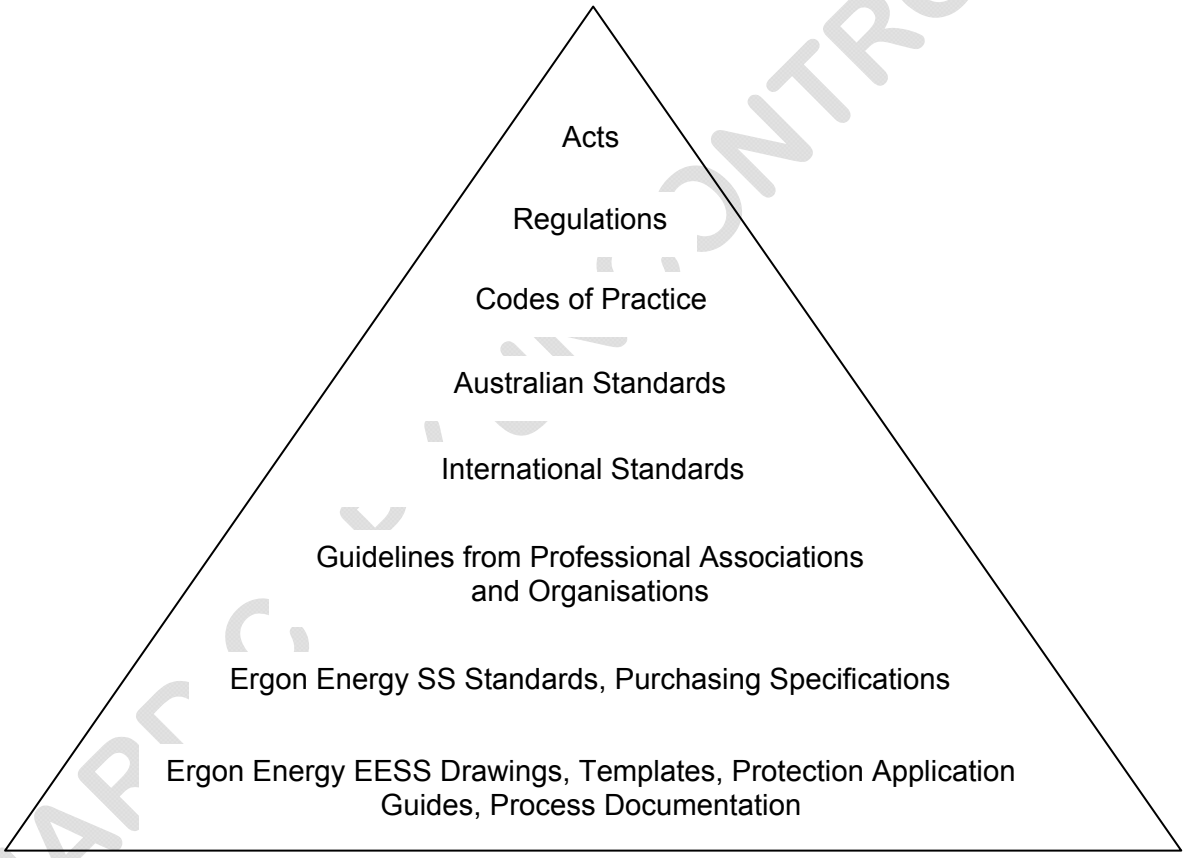
6. LEGISLATION AND STANDARDS

All design work, and the associated supply of materials and equipment, must be undertaken in accordance with **all** relevant Legislative and Regulatory requirements, the latest revisions of the relevant Ergon Energy Asset Management Standards, Specifications and EESS drawings, and the relevant Australian Standards.

Where no Australian Standard exists, then the latest revision of the relevant International Electrotechnical Commission (IEC) Standard, British Standard (BS), or the NATSPEC BASIC Standard (in that order of preference) applies.

Any deviations from the Ergon Energy Standards and Specifications must be with the approval of Asset Management and following approval must be clearly stated in the Project Design Documentation. A documented and approved risk assessment must be produced in consultation with the relevant SME's in instances where the Project Scope Statement or Project Sponsor directs work to be undertaken which is not in accordance with the standards.

The hierarchy of documentation that must be adhered to for all designs is:



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6.1 Asset Management Standards

All Substation Design work must comply with the requirements of the Ergon Energy Asset Management Substation Design Standards (STNW series, or SS-1-n.n and SS-2-n.n series) which include Primary Plant Standards, Secondary Standards and Civil Standards (refer to References Section 4.2).

6.2 Technical Specifications

All Substation Design work involving the procurement of material and equipment must comply with the requirements of the Ergon Energy Asset Management Plant and Equipment Technical Specifications (SS-5-n.n series).

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6.3 Zone Substation Standards, Templates and Design Modules

Ergon Energy Asset Management have a range of Standard substation designs that cover the major substation types for both Sub-Transmission and Zone Substations. These standard substation designs are commonly known as the ZSS standards and include for each standard substation type:

- Design Philosophy
- Functional Specification
- Concept Design
- Design Report
- Fact Sheet

Supporting the standard substation designs are standard materials in the form of equipment specifications, period contract high voltage plant and equipment stock items as well as approved template drawings.

The ZSS substation types include:

Type S – Sub-transmission Substations

Network Connection		
S1	132/66	Ultimately an “N-1” design based on two primary feeders, two transformers, all switchgear and buswork is outdoor, except for 33kV where indoor is available.
S2	132/33	
S3	110/66	
S4	110/33	

Type Z – Zone Substations

Network Connection		
Z1	132/22	Ultimately an “N-1” design based on a minimum of two primary feeders, two transformers, and a three section secondary busbar. At 66kV and above the bus is outdoors. Lower voltages use indoor switchgear.
Z2	132/11	
Z3	110/11	
Z4	66/33	
Z5	66/22	
Z6	66/11	
Z7	33/11	

Type T – Transportable Substations

Network Connection		
T1	66/33	“N” design based on one primary feeder, one transformer, switchgear is indoors except at 66kV. Two units can be used together to give “N-1”
T2	66/22	
T3	66/11	
T4	33/11	

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Template drawings that support the standard substations are stored in the EDMS and are identified as an approved standard substation template drawing by the 'EESS-' prefix to the drawing number. The template drawings are bundled together to create standards design modules, eg. a 66kV Feeder Protection Panel module. A list of the standard design modules is included in ANNEX I – STANDARD DESIGN MODULES.

6.4 Reference Documents

Additional Ergon Energy controlled reference documents relevant to Substation Design are listed in SS-1-1.4 Substation Design Requirements.

6.5 Australian and International Standards

Additional Australian and International standards relevant to Substation Design are listed in SS-1-1.4 Substation Design Requirements.

Where Ergon Energy's Asset Management Standards conflict with Australian or International Standards, then the Ergon Energy requirements must apply.

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7. QUALITY MANAGEMENT

Ergon Energy's Customer Service Group, which encompasses Substation Design Groups, has a Quality Management System (QMS) which is certified to ISO9001 for managing the process of Substation Design Works. The Ergon Energy Substation Design Quality Management System consists of a series of Work Instructions, Forms and Reference Documents that outline how a Substation Design Project is accepted, reviewed, initiated and completed. Refer to References Section 4.1 NI00xxx numbered documents for a complete list of the QMS documents. Ergon Energy designers and managers must ensure all designs are produced in compliance with these documents.

The QMS documents below are the specific work instructions that detail the Ergon Energy substation design process.

Process Document	Actioned By
NI000201W101 Plan Schedule and Resource Design Work	Design Manager
NI000401W101 Prepare Design Inputs	Design Manager
NI000401W103 Produce and Verify Concept Design	Project Design Team
NI000401W104 Perform Detailed Design Work	Design Manager
NI000402W100 Initiate Procurement of Equipment & Materials	Project Design Team
NI000401W105 Produce Design Outputs	Project Design Team
NI000401W106 Obtain Project Owner Verification	Design Manager
NI000401W107 Issue Final Design Documents	Design Manager
NI000303W100 Complete Post Commissioning Requirements	Design Manager

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8. PROJECT DELIVERY

8.1 Project Phases

To provide an integrated design, all design deliverables for all design disciplines must be provided for each phase of a project.

The Ergon Energy project delivery model comprises four distinct phases being:

(a) Concept Phase

This phase normally commences with the issue of a Recommended Works Report (RWR) and is complete at the initiation of an approved project (PIA).

The milestone for this phase is WPIA (Works Planning Project Initiation Advice).

The concept design can consist of a number of options and has the following deliverables:

Design Discipline	Deliverable
Substation Design	The following design drawings may be produced or updated for a concept design. Single Line Diagram Operating Single Line Diagram Plant Single Line Diagram Protection and Metering Single Line Diagram Communications and SCADA General Arrangement Plan (where applicable)
Civil Design	SME advice to General Arrangement, Concept Sketches (where applicable)
SCADA Design	SME advice to Single Line Diagram Communications and SCADA
Communications Design	SME advice to Single Line Diagram Communications and SCADA
Protection Design	SME advice to Single Line Diagram Protection and Metering Protection Review as required

(b) Development Phase

For the development phase of a project, a project delivery summary would typically encompass:

- The Substation Design Group produce client verification drawings for sponsor signoff. These drawings include all of the Single Line Diagrams and a General Arrangement.
- Substation Design Group provides approved Single Line Diagram Operating to Network Data Group
- Coordination between the substation and civil design groups for main earth grid and earthing tails, conduits, underground services, and clearances
- Substation and Civil Designs produced to check stage. Bill of Materials compiled.
- At design check stage (70% design complete), preliminary design drawings submitted to Protection, SCADA, and Communications Design Groups to progress these designs
- Substation and Civil Designs completed and approved. Material requirements finalised and approved.
- Approved Designs sent to Protection, SCADA, and Communications for completion and approval of these design groups individual designs.
- Work Specification completed and approved

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- All Design Drawings RPEQ approved, transitioned to “Released for Construction” state in EDMS, printed to an electronic drawing set (Adobe pdf) and issued to the Project Manager together with Transmittal (NI000401F104), Work Specification and Bill of Materials

This phase normally commences with the issue of a Project Initiation Advice (PIA) and is complete at the handover of an approved, integrated design.

The milestone for this phase is Design Complete (DC)

The development phase has the following deliverables:

Design Discipline	Deliverable
Substation Design	Site Acquisition Project EMF Model and Report (as required) Noise Model and Report (as required) General Arrangement Plan (Ultimate Requirements) General Arrangement Elevations (Ultimate Requirements) Single Line Diagrams (Ultimate Requirements) Design Projects Earthing Report as required Insulation Coordination / Lightning Study as required Approved Drawings in EDMS Substation Operating Manual (new, or updated as required) Electronic copies of SLD Operating to Network Data and OCC, in accordance with NI000401R117 & NI000401R118 (Copies 2 & 3) Electronic set (pdf) of all approved drawings issued to Project Manager Bill of Materials Works Specification
Civil Design	Site Acquisition Project Geotechnical Assessment and Report Bulk Earthworks (including erosion and sediment control), Drainage, Access, Signage and Fence Design as required Work Specification as required Approved Drawings in EDMS Design Projects Approved Drawings in EDMS Work Specification Form 15 – Compliance Certificate for Building, Design or Specification
SCADA Design	All SCADA Points on approved Substation Drawings entered into SSDB All SCADA Points from Standard Protection Application Guide Drawing are entered into SSDB SCADA Picture Frameworks for Ventyx SCADA and Wonderware are created
Communications Design	All CAD Drawings including Equipment Layout, Communications Connections, DC Supplies, Engineering Access, and Schematics

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	Stride Visio and Stride Database (MUX and Cable) showing extra equipment and circuits Engineering Access (Lantronix) Allocation Spreadsheet (where applicable) Construction Scope
Protection Design	Approved Protection & Metering Single Line Diagram Relay Specified Protection Application Guides specified Departures from the Protection Application Guide specified

(c) Implementation Phase

This phase commences at the handover of the approved designs and is complete at the issuing of the Certificate of Practical Completion.

The milestones for this phase are CCM (Construction Commenced), FCA (First Capacity Available), and CPC (Certificate of Practical Completion)

The Design Groups provide construction support activities during the implementation phase of a project and have the following deliverables:

Design Discipline	Deliverable
Substation Design	Hard copy, stamped design drawing sets issued to relevant construction groups, in accordance with NI000401R117 & NI000401R118. SME Advice / Construction Support
Civil Design	SME Advice / Construction Support
SCADA Design	Verify Protection Points from Protection Setting Requests (PSRs) Create ABB and HMI Links omitting unused points from the Protection Application Guide. Load Database Points into Ventyx and Wonderware Link Database Points to the Displays Update Overviews and Feeder Pages Update Trends and Bar Graphs Test and Commission all points to the RTU from Wonderware and Ventyx Clean-up of old data
Communications Design	MUX Configurations (DN2, DB2LP, Marconi, Alcatel, Ceragon) Assistance in loading configurations Stride MUX and Cable drawings changed from Planned to existing during commissioning Assistance in adding new cross-connects
Protection Design	Prior to Construction commence, issue Operational Settings Prior to Construction commence, issue Protection Settings Report SME Advice / Construction Support

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(d) Finalisation Phase

This phase generally commences when First Capacity is available (FCA) and is completed by project close out.

The milestone for this phase is PCO (Project Close Out).

The Design component during Project Finalisation has the following deliverables:-

Design Discipline	Deliverable
Substation Design	As Built Drawings completed and approved in EDMS Substation and Test Copy As Built Drawings distributed Plant Documentation/Manuals in e-library or EDMS
Civil Design	As Built Drawings completed and approved in EDMS
SCADA Design	SCADA Databases finalised As Built
Communications Design	As Built Drawings completed and approved in EDMS Stride MUX and Cable Drawings. Database finalised As Built
Protection Design	Protection settings finalised in protection database

8.2 Project Types, Site Acquisition, Greenfield, Brownfield

Projects in Ergon Energy can be generally classified into 3 types, being:-

Site Acquisition

Acquisition projects include new substation sites and line easements. The Designer may be involved as a Subject Matter Expert to assess the suitability of potential substation sites. In assessing a potential substation site, the Designer should consider the requirements as detailed in Ergon Energy Standard SS-1-1.4 Substation Design Requirements Section 25 Site Requirements. Refer also section 11.3 of this manual.

Greenfield

Greenfield projects are projects at new substation sites where there is no existing electrical infrastructure. All greenfield projects must be designed strictly in accordance with the Zone Substation Standards.

Brownfield

Brownfield projects are projects at established sites where there exists energised, electrical infrastructure. Brownfield projects must be designed generally in accordance with the Zone Substation Standards while considering the interface to the existing High Voltage Plant and Secondary Systems equipment. Brownfield considerations for the Designer on how to manage the interface between new and existing plant and equipment can be found in this manual.

8.3 Project Staging and Contingency Planning

The Designer must consider the constructability of the project design with regards to the construction costs and duration, Network security, and customer outage durations during construction. At the completion of the client verification drawings showing the final arrangement for the project, (Single Line Diagrams, General Arrangements, and Feeder Arrangements), the Designer in conjunction with the Project Manager must consult with the Commissioning group and Construction Coordinators to assist in the development of the project staging plans and commissioning schedules. Additional details and requirements can be found in the Ergon Energy MN000301R171 Test and Commissioning Manual.

The project staging plans that are developed may require additional designs, including staged SLDs, temporary GA's, and staged secondary systems designs to be provided to ensure that at

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each stage of the construction and subsequent testing/commissioning, there is an accurate representation of the state of the Network asset. The Single Line Diagram Operating for a substation must at all times accurately represent the operational state of the substation. To achieve this during the project stages the Designer must consult with the Network Operations group to determine the exact requirements, including approvals and issue, for the production of the staged SLDO's.

In consultation with the Project Sponsor, Project Manager, Network Operations, and Asset Managers, there may be a requirement to design and install contingency assets in the form of temporary HV plant and/or temporary secondary systems equipment to minimise the impact of inadvertent outages during construction and to maintain the required security of supply. The design of all contingency plant and equipment, including the specification of all materials, and the management of the design drawings, must be in accordance with the substation design quality management process.

8.4 Drawings

A design deliverable for all substation projects are completed sets of design drawings. The design is not considered complete until all project design drawings are approved in the EDMS and transitioned to either the Released for Construction state for construction drawings, or the Final Release state for As Commissioned projects. Specific requirements for the management, types of substation drawings, and drafting can be found in section 9 of this manual.

The Designer must ensure all project drawings issued for a project are accompanied by a document transmittal note (refer NI000401F104 Transmittal Note) and managed in accordance with Ergon Energy Work Instruction NI000401R117 Substation Controlled Drawings.

8.5 Bill of Materials

It is the Designer's responsibility to collate from the design drawings all the materials required for the project (except Civil) and include these on a Bill of Materials (BOM).

The BOM must include all of the required information to enable procurement and collection of the items as needed and must be in a format compatible with NI000402F100 Equipment and Materials Procurement List.

Some items may have already been selected during the concept development phase and ordered to meet the project delivery timeframe.

The Designer must take design responsibility to ensure the suitability of all plant and materials for the project, including the pre-selected items. Accordingly, the Designer must check and verify the suitability of the materials on order and highlight to the Design Manager any discrepancy as early as possible in the design process.

To ensure standardisation of equipment and materials for all projects, the Designer must specify materials from Ergon Energy's period contract and stock items in the first instance. A catalogue of substation materials, including stock codes is available to assist the Designer. Details of any items selected for the project that are not stock items must be forwarded to the Design Manager for possible stock coding.

The Designer generally will not specify on the BOM minor materials and consumable items such as bolts, nuts, screws, cable & wire numbering ferrules, terminal lugs for LV cables, miscellaneous terminals, LV cable clamps and ties, grease, cleaning liquids etc. These will normally be supplied by the Constructor.

The BOM must include the responsibility of supply for all items. For some items, this may need to be decided on a case by case basis in consultation with the Project Manager.

The Designer must provide to the Project Manager or Design Manager an updated version of the Bill of Materials on request and at each design review.

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The Designer (or Technical Representative in the case of contract design works) must load the project BOM as materials requirements against an Ellipse estimate. The Ellipse estimate must align to the standard structure and format as required by the Ergon Energy Estimating Group.

The BOM must be stored with the project documentation, and is a mandatory design deliverable to be included in the project handover to the constructor.

A civil BOM will not be produced for the project and it is expected that the civil constructor will estimate the required quantities to complete the civil works from the project documentation.

8.6 Material Ordering

The Designer must ensure that any items on the BOM with lead times that may impact on the project delivery timeframe are identified to the Project Manager or Design Manager for ordering as early as possible in the design process. This will necessitate that the Designer (or Tech Rep for contract works) will be responsible for placing orders for major plant items on period contract and other items with long lead time delivery.

The Designer must also consult with the Project Manager in relation to ordering of items with medium lead time (eg. protection relays, control cables, etc), as these may need to be ordered sufficiently ahead of construction approval, in order to enable prompt commencement of panel and modular building manufacture etc.

On commencement of construction, the Constructor will take over responsibility for maintaining the BOM, keeping it up to date with details of equipment and materials ordered, received, etc. Procurement of any miscellaneous items indicated on the BOM as still unordered, plus all consumable items is the responsibility of the Constructor.

Refer also to Clause 8.4 of NI000401R122 Ergon Energy Substation Construction Manual for further information in relation to the Construction phase of project works.

8.7 Work Specifications

A Works Specification must be produced for all projects and is a mandatory design deliverable. The Works Specification contains or references the Design and/or Construction requirements that apply to the Design Contractor and/or Constructor performing the Works including:

- Project Overview
- Electrical Design Scope of Works
- Civil Design Scope of Works
- Civil Construction Scope of Works
- Electrical Construction Scope of Works
- Electrical Test and Commissioning Scope of Works
- General Requirements

Refer to Ergon Energy Substation Works Specification Template

The completed Works Specification for a project must be allocated an EDMS document number, entered into the EDMS, and checked/approved in accordance with the Substation Design approval process. The EDMS must be used to track all updates and subsequent revisions of the project Works Specification.

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9. DRAWINGS, DOCUMENTATION AND RECORDS

9.1 Electronic Document Management System (EDMS)

All drawings are to be stored in the Ergon Energy Electronic Document Management System (EDMS). This database system provides a means of electronic storage, management and control. Its use is crucial to the Quality Management System for substation design work as it provides a means of electronically approving designs. The standard drawing borders have interactive database field links with the EDMS for automatic population of title block information. The EDMS is linked to other software programs such as Microstation, AutoCAD, Word and Excel. The Designer must be familiar with and follow the EDMS Manuals when performing design works. Refer to References Section 4.3 for EDMS Manuals.

9.2 Drawings (Physical, Schematics, Schedules)

9.2.1 Drawing Types (Overview)

The drawings required for a substation project must generally be in accordance with those as listed in ANNEX J – SUBSTATION DRAWING LIST. Substation Project Design Drawings include Single Line Diagrams (SLD's) General Arrangements (GA's) in plans and elevations, material lists, earthing, conduit, foundations and steelwork details, panel layouts, schematics, connection diagrams and cable schedules.

Single Line Diagrams illustrate the logical functioning of the primary plant and secondary protection, control, indications and communications. General arrangements describe the physical primary plant and electrical connections. Layouts, schematics, connection diagrams and schedules detail the secondary equipment, locations and terminations.

9.2.2 Drawing Approvals

In accordance with the requirements of the Professional Engineers Act 2002 (Qld), it is mandatory that all design be either carried out by an appropriately qualified and experienced Registered Professional Engineer of Queensland (RPEQ), or be directly supervised by the RPEQ.

Ergon Energy requires further that all new or modified drawings produced as part of a project design must be individually approved (certified) by the appropriate RPEQ, who having had reasonably close oversight of the production of the design, will be familiar with it.

For internally produced designs, the relevant RPEQ or delegate provides approval by transitioning the drawings to a "Released for Construction" or "Final Release" state in the EDMS, as appropriate. This action records the RPEQ or delegates name and approval date in the EDMS and populates the design drawing signature block.

For externally produced designs by contractors, the contractor must provide the RPEQ certification via an electronic stamp that will remain on the drawing, independent of the transitioning of the drawing through the EDMS. The stamp must include RPEQ number, date, revision number and signature.

When an existing approved (RPEQ certified) Ergon Energy standard design is used for a project, eg. standard steel supports and associated footings, there is no requirement to re-certify these individual standard designs, however it is a requirement that the application of the standard designs into the project has RPEQ certification. i.e. the Substation General Arrangement, plus any modified structure and footing designs. This is necessary to confirm that the structures have been selected appropriately to ensure that the combinations of footings, structures and HV equipment are appropriate to meet the required design criteria for wind and short circuit loading, electrical clearances, substation layout, soil type, etc.

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9.2.3 Project Owner Design Verification

Prior to commencement of detailed design, the set of high level drawings listed below must be submitted to the Project Owner for Verification as per process document NI000401W103 Produce and Verify Concept Design.

The required drawings are:

Single Line Diagram – Plant

Single Line Diagram – Operating

Single Line Diagram – Protection and Metering

Single Line Diagram – Communications and SCADA

Switchyard General Arrangement

These drawings will be based on the initial concept drawings provided for the project, subject to any minor modifications approved by the Project Owner.

Prior to submission for Verification, the design drawings must be checked and approved by the Design team, including the relevant RPEQ approval.

Each drawing must be stamped with a red Client Verification stamp and forwarded via the Design Manager (or Tech Rep).

9.3 Equipment Identification

The general requirements for substation electrical design drawings with respect to equipment identification codes, voltage colours for single line operating diagrams, indicator light colours, small wire numbering and small wire colouring must be in accordance with Ergon Energy Standard SS-1-1.2 Substation Standard Equipment Identification. This standard must be applied to all new greenfield substation designs or where total replacement is occurring. Where a whole section is being replaced or reworked, such as a new panel or bay, it is desirable for this standard to be applied.

Operational equipment identification as shown on the substation SLDO must be in accordance with Ergon Energy STNW1169 Standard for Network Operational Identification and Naming. This standard must be applied to all new greenfield substation designs or where changes to 50% or more of the primary plant at a specific voltage level is occurring. It is not necessary to change the operational identification of all primary plant within the substation at all voltage levels. A small change at a brownfield site will continue to employ the existing in-situ identification convention.

9.4 CAD

9.4.1 CAD Standards - General

All Ergon Energy Electrical Design Drawings must be produced using Bentley Microstation. Conversion from AutoCAD or other formats is **not** acceptable. Other drawings (e.g. Mechanical and Civil) may be produced in AutoCAD format.

All drawings must be clear and legible without imperfection of any sort in the printing or reproduction.

Dimensions of drawings must be in accordance with AS1000, the International Systems of Units (SI) and its application.

Drawings must conform to the following Australian Standards:

- AS1100 Technical Drawing
- AS1101 Graphical Symbols for General Engineering
- AS1102 Graphical Symbols for Electrotechnical Documentation
- AS3883 Computer Graphics – Computer Aided Design (CAD)

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All design drawings must comply with the Ergon Energy CAD Standards Manual. An external user CAD configuration is available. This includes borders, cells, text styles, line styles, dimension styles, levels and seed files required to conform to the standards. The Manual provides guidelines on sheet sizes, revision numbering, file naming, drawing grid and how to use the Microstation design model and sheet model.

All physical drawings (GA's, panel layouts, etc.) must be drawn 1:1 in the design model and referenced into the sheet model at an appropriate scale. The border, text and dimensions are to be included in the sheet model.

All electrical drawings (SLD's, schematics, connection diagrams, etc.) must be drawn in the sheet model. A border of an appropriate size to fit the design is selected and the design is drawn within the border area.

9.4.2 Hybrid Drawings

A hybrid drawing consists of a raster file (scanned image of a drawing) linked to a vector file (CAD file). The Bentley Descartes program operates with Microstation to create hybrids. Physical rasters must be entered 1:1 in the design model and electrical rasters must be incorporated in the sheet model. Include the raster revision information.

When working with a raster, ensure that the original file is added to the EDMS prior to beginning current works to maintain design history. Consider the possibility of redrawing a hybrid as a complete vector file only. A good rule of thumb is if it will take less than eight hours to redraw then redraw is viable. Other considerations are the impact of future works and the importance of the drawing itself such as SLD's. Discuss the viability with the Project Design Manager.

9.4.3 CAD Standards Workspace

Ergon Energy has a configuration for Microstation that standardises the way CAD drawings are created. When the program starts and closes a macro is run in the background that sets the workspace to a normal status that includes changing to the sheet model view, removing any view rotations, fitting all elements to the screen and many other actions that are listed in the Ergon Energy CAD Standards Manual.

The substation design workspace includes standard text, lines and dimension tools that make the CAD drafting process more efficient. Special line styles are used for SLDs that symbolise functions such as current and voltage transformer supplies or tripping of circuit breakers. These are accessible from the Microstation task dialog box which consists of tool palettes that are docked on the left hand side of the Microstation application window. Standard borders are accessible from the 'Ergon' menu at the top of the Microstation application window.

9.4.4 Seed Files

Seed files are base Microstation templates that include the Ergon Energy CAD Standards. For an electrical or physical drawing the Ergon_seedgen_mm.dgn file must be used. If the drawing is of a large site layout then the Ergon_seedgen_m.dgn may be used.

9.4.5 Cells

Cells are created symbols drafted in Microstation to make the CAD process more efficient. They include relays, contacts, switches, LED's as well as items of major plant such as current transformers and disconnectors. Commonly used cells have been made available in the Microstation task dialog box. Other cells may be accessed using the menu selections of 'Elements – cells'. This gives the user access to folders that have cells stored in them.

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9.4.6 Creating a New Drawing

When creating a new drawing the latest approved seed files must be used. When creating a new drawing an appropriately sized border is chosen and the design is begun. The drawing must comply with all Drafting Standards, Substation Standards, Design Templates and Manuals. All Design Drawings must be added to the EDMS as per EEAD-0003 EDMS Author Manual.

9.4.7 Revising an Existing Drawing

Revising a previously released or approved drawing must be done through the EDMS. The EDMS will automatically perform the revision, update the database information and rename the file. Within the EDMS you still need to manually change the data fields 'Created By' and 'Project Number'. The drawing can then be checked out, worked on and checked back into the EDMS on completion. Refer to EEAD-0003 EDMS Author Manual.

When revising an existing drawing the latest approved seed files must be applied.

All drawings that are being revised must have new borders applied. Before a new border is placed the existing border must be removed using the 'Ergon' menu items. The new border database fields contain default information. To avoid overwriting the EDMS data the drawing must be closed but not checked back in. Open the dgn file using Microsoft Explorer and the EDMS link macro will run which will automatically populate the border with the correct EDMS database fields.

9.4.8 Clouding

Clouding is used to identify or highlight on a drawing where changes or additions are required. If the drawing is of a completely new panel with all new equipment then no clouding is required. However, if the panel is existing but all the equipment is new then the new equipment must be clouded. The clouding should encompass only the new or changed components. This is very important as it is the only way that Construction and Commissioning Staff can ascertain what work is needed to be done.

To cloud an entire terminal block when only adding one terminal to the block is misleading and will make the construction service providers believe and estimate the addition of the entire block that may have CT or VT circuits that need to be accessed and isolated.

When checking and approving drawings clouding must be rigorously reviewed. Microstation includes a cloud tool that can draw a cloud or can change a series of joined lines into a cloud. To maintain a consistent look and feel across the drawing only use the one radius size for all clouding. This is easily achieved using the tool that is available from the Microstation task dialog box. Accurate clouding results in clear design interpretation for approvals, estimating, construction, commissioning and markedly reduces the number of support calls when construction service providers are on-site.

9.4.9 Concurrent Projects at a Substation

Multiple projects may occur at a substation at the same time. This can be due to project time delays, failed in service projects or project staging that has not gone as planned. The Designer must take care in the management of drawing revisions, clouding, document states, and the tracking of the As-Built mark-ups.

When multiple projects require design changes on the same drawing, each separate project must be identified by a revision triangle which is placed inside or adjacent to the cloud. These should be grouped with the clouds to simplify removal when doing the as-built drawings.

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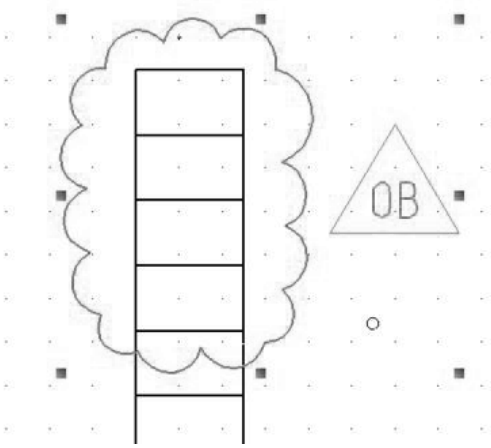
Example:



On receipt of the as-built drawings, the Released for Construction Drawings must be up-revved in the EDMS, and the clouding for only the projects where the as-built drawings have been completed must be removed. All other clouding for future projects must remain on the drawing. If the as-built drawings returned are for more than one project at the site, then each project must be referenced separately in the revision note.

As-Built Drawings with future project works must be transitioned back to a Released for Construction state. At no time must a Final Release Drawing contain revision clouds for future project work. Drawings that have been amended as-built and still contain future project works must be issued back to field crews and to the substation as the latest record of completed works. It is suggested that these drawings be identified on the document transmittal as not being in a Final Release state. All previously issued drawings for future construction works must be destroyed and replaced with the current revision.

9.4.10 Releasing drawings for construction

All designs must be checked and approved by authorised staff when completed. They are then transitioned in the EDMS to a 'Released for Construction' state. Drawings are printed, collated into drawing sets with a transmittal and sent to the Project Manager for distribution to Service Providers and Stakeholders. Refer to NI000401W105: Produce Design Outputs Work Instruction Manual.

9.4.11 CAD Drafting Hints and Tips

A number of specific hints and tips for Ergon Energy CAD users is included in ANNEX A – CAD HINTS AND TIPS. These drafting tips are predominantly for electrical designers using Bentley Microstation and are included to provide assistance and clarification to the Designer to produce drawings to the required CAD quality. They should be used by the Designer to supplement the Ergon Energy CAD manual, not as a replacement to the CAD standards.

9.5 Single Line Diagrams

Substation Single Line Diagrams (SLD's) are a simple, one line representation of the installed substation HV plant and the associated secondary systems.

The Substation SLD's are initially produced for a project during concept phase and form part of the drawing package required to be submitted for customer verification before detailed design commences.

Brownfield Site Considerations

Where significant augmentation work is being undertaken at an existing substation, the Designer should give consideration to producing a new set of SLD's to the latest standards for the substation. Examples include full or significant protection upgrades, replacing or installing new SCADA systems, major extensions to switchyard, rebuilds of existing substations.

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For all new substation installations and where significant augmentation is undertaken on existing substations, the following SLD's must be produced as a drawing series.

Sheet 01 – Single Line Diagram Operating (SLDO)

The SLD Operating represents the installed HV plant only and the assigned operational numbers to that plant in accordance with the Network Operational Naming Guidelines. It is essential that every substation has a Single Line Diagram Operating. For an example of a substation SLDO and the associated Ergon Energy standard, refer to:

- STNW1169: Standard for Network Operational Identification and Naming
- EESS-10480-01: Z6-32D Single Line Diagram Operating

Alterations to the Substation SLD Operating must be checked and approved by Substation Design in the first instance and then transitioned in the EDMS for business approval by the appropriate Principal System Operations Engineer or representative (according to the Operating region of the substation). It is the Design Manager's responsibility to ensure any update to a Substation SLD Operating that a pdf copy is sent to Network Data Group to maintain plant asset records.

Initial creation and subsequent updates of the SLDO in Smallworld by Network Data is the trigger for other Ergon Energy processes, including the creation of the Ellipse asset functional locations, and the substation asset structure in the Protection Settings database. It is important that the SLDO in EDMS is created and amended in accordance with the Ergon Energy EEAD-0060 EMDS Single Line Diagram Operating User Guide to ensure all processes reliant on the SLDO are invoked correctly.

The Single Line Diagram Operating must be one of the first design drawings to be created for a project, and must be approved and submitted to Network Data prior to any detailed design being undertaken. See also section 9.7 of this manual for details on equipment records.

Sheet 02 – Single Line Diagram Plant

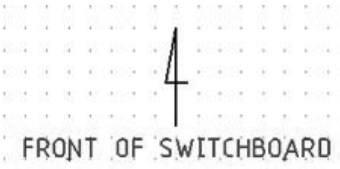
The SLD Plant represents the installed HV plant only and the assigned equipment identification numbers to that plant.

For an example of a substation SLD Plant and the associated Ergon Energy standard, refer to:

- SS-1-1.2 Substation Equipment Identification
- EESS-10480-02: Z6-32D Single Line Diagram Operating

Substation SLDs should whenever possible, be drawn to best represent the physical layout of the HV equipment. When representing a HV switchboard on the SLD, sometimes due to building arrangements or HV cabling the order of the switchboard feeders shown is opposite to the physical arrangement to avoid a crossover of transformer incomers in the middle of the SLD. To represent the correct order and to avoid drawing cable cross-overs, a symbol must be added to the SLD to display which side the switchboard is being viewed from.

Example:



Switchboard circuit breakers can be used to earth feeders, transformer cables and bus sections. These earthing positions must be shown on the SLD for staff to operate the equipment correctly.

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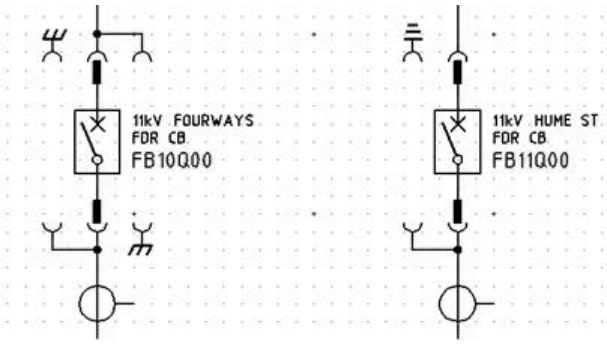
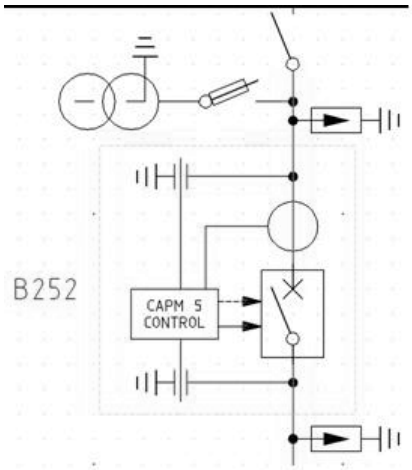
Example:



Reclosers are a small pole mounted circuit breaker that can contain in-built protection systems and communications. When they are used within substations their internal CT's and CVT's and any associated external CT's and VT's must be shown correctly on the substation SLD's.

Example:



Sheet 03 – Single Line Diagram Protection and Metering

The SLD Protection and Metering represents the installed protection schemes for the substation, all statistical and relay metering, and all SCADA transducers. This includes, but is not limited to, relay function and designations, CT/VT connections to the relays, meters, and transducers, VT selection schemes, all circuit breaker trip/close circuits, circuit breaker fail initiate and trip circuits, and signalling schemes. Every substation must have a Single Line Diagram Protection and Metering. For an example of a substation SLD Protection and Metering, and the associated Ergon Energy standard, refer to:

- SS-1-1.2 Substation Equipment Identification
- EESS-10480-03: Z6-32D Single Line Diagram Protection and Metering

Sheet 04 – Single Line Diagram Communications and SCADA

The SLD Communications and SCADA represents the installed Communications and SCADA equipment and schemes for the substation. This includes, but is not limited to, Analogue Transducers, Digital Input, Digital Output and serial data communications between IEDs, HV Plant, and the RTU's, RTU and HMI Network connections, Ethernet network and switches, Engineering Access to all devices, substation multiplexers, media converters, modems, communications carriers, telephony and signalling. For an example of a substation SLD Communications and SCADA, and the associated Ergon Energy standard, refer to:

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- SS-1-1.2 Substation Equipment Identification
- EESS-10480-04: Z6-32D Single Line Diagram Communications and SCADA

Sheet 05 – Single Line Diagram Revenue Metering (if applicable)

The SLD Revenue Metering represents the installed Revenue Metering equipment and connections to the associated CT/VT's and remote communications for the substation. In accordance with the Australian Energy Market Operator requirements, the SLD Revenue Metering must include, but not limited to, metering installation type, connection point identifier, HV connection location, accuracy and performance class of all CT/VT's and meters, meter auxiliary supplies, remote communications and meter interrogation. For an example of a substation SLD Revenue Metering, and the associated Ergon Energy standards, refer to:

- SS-1-1.2 Substation Equipment Identification
- SS-2-4.1 Metering
- EESS-10480-05: Z6-32D Single Line Diagram Revenue Metering

9.6 Plant Manuals

Operations and maintenance manuals for substation plant are stored in the Ergon Energy library in either hard copy or electronic format. It is the responsibility of the substation standards group to ensure the manuals and any associated test reports for all period contract plant items are submitted to the library for registration and storage. It is the responsibility of the relevant design group to ensure all other purchased plant items, i.e. those not covered under a period contract, are submitted and registered in the library.

To register a library document for substation plant:

- the Designer creates an EDMS document against the relevant asset identifier for the equipment. This EDMS document number becomes the document registration number for the copy of the document held by the library. Plant manuals and test reports are registered in the EDMS against the substation asset identifier for any plant that is considered as being specific to the particular substation, i.e. switchboards, capacitor banks, AFLC plant, etc. Any standard, period contract plant, or plant not specific to the substation site, will have the manuals and test reports registered in the EDMS against the specific plant asset identifier, i.e. disconnectors, current and voltage transformer, circuit breakers, power transformers etc.
- a Transmittal Note and Registration form must be completed and added to the EDMS document record. This form records all of the relevant plant data to assist registration and searching of the document in the library system. Refer to BS001603F100 Transmittal Note - eLibrary Storage and/or Registration Form
- all copies of the manual or test report (hard copy and/or electronic) are sent with the Transmittal Note and Registration form to the library
- the library will register the documents in e-library, and send out copies to the relevant groups as identified on the transmittal note.

9.7 Equipment Records

The registration and identification of the locations of substation plant assets in the Ergon Energy asset register is developed initially from the substation SLDO. The Designer must ensure all new, and any changes to existing substation SLDO's are communicated to the Network data group for creation/update of the Smallworld asset, and subsequent upload to the Ellipse asset register. This is essential to ensure that the commissioned plant assets are registered against the correct position (eg. feeder bay, phase etc.) in the substation.

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All plant purchased on contract through the Ergon Energy store will have a new equipment record created by the Logistics group in the asset register. The suppliers/manufacturers of the plant and equipment that is purchased through a period contract will submit a data load sheet (that records the asset and nameplate data) to the Logistics group for all plant and equipment prior to delivery. This load sheet is uploaded into the asset register against the associated plant/equipment item.

The Designer must ensure that any plant or equipment assets that are direct purchased (i.e. not on contract as Ergon Energy stock), and are required to be registered in the asset register, an asset is created and the data load sheet completed and forwarded to the Logistics group.

The field asset data for the plant and equipment must be recorded by the constructor for uploading into the asset register and updating of the asset into its correct position. Refer NI000401R122 Ergon Energy Substation Construction Manual Clause 15.8 Commissioned / De-commissioned Plant Data Capture Forms for detail.

9.8 Substation Operating Manual

In accordance with AS2067 Section 10, Operation and Maintenance Manual:

> *Each installation should have an operation manual describing the normal, emergency and maintenance procedures as well as safety instructions for the operation of the high voltage electrical installation.*
>
> *Each installation should have a set of up to-date drawings and operating diagrams on the premises. These drawings and diagrams should allow operation and maintenance personnel to provide safe and efficient interventions in the installation.*
>
> *Manufacturers of major components of an installation should provide operation and maintenance manuals and test and in-service reports. These documents should be readily available for use when necessary.*

It is a Substation Design responsibility to provide this Manual, and a template index for its development can be found in QMS documentation. Refer to NI000401R116: Index for Substation Operations Manual.

Completed Substation Operations Manuals should be stored electronically in the EDMS against the substation asset identifier and a printed copy to remain at the substation.

9.9 As-Built Drawings

A controlled process exists for the issue of Project Design Drawings and the return of the As-Built mark ups. This process must be used for all Ergon Energy projects and it ensures drawing sets and mark up procedures are standardised. A summary of the process is:

- Project Management receive the same drawings set's irrespective where the design is completed.
- At the development phase all design service providers produce the same range of drawings.
- The Controlled Drawings belong to the Service Provider carrying out the actual activities and the individual work groups.
- All Construction Service Providers transfer mark up's to master copy and sign master copy prior to completion of work.
- All Test Service Providers obtain mark up's from master copy prior to testing, transfer mark up's to master copy prior to completion and sign master copy.
- With the exceptions on the SLDO all work groups will get all revisions so they are aware of changes on the project

Refer to NI000401R117 Substation Controlled Drawings and NI000401R118 Substation Controlled Drawings Quick Reference Guide

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10. ENVIRONMENT

10.1 General

Ergon Energy is committed to responsible Environmental Management ensuring all business activities associated with the supply of electricity are carried out with as little adverse impact on the environment as possible.

Environmental considerations and relevant publications are detailed in SS-1-1.4 Substation Design Requirements Section 7. The Environmental requirements required by Ergon Energy for use in contracts for work to be conducted for Ergon Energy can be found in reference document MP000903R117 Environmental Protection Requirements.

10.2 Ergon Energy Environmental Policy

Ergon Energy is committed to compliant, responsible and sustainable Environment and Cultural Heritage operating principles and practices for the benefit of current and future generations.

Ergon Energy will be a leader in Environmental and Cultural Heritage Management in the electricity sector.

10.3 EMF

Ergon Energy has a policy of acting prudently in relation to EMF when designing or maintaining network assets such as substations. EMF planning and implementation considerations, recommended acceptance EMF levels, and relevant publications are detailed in the following Ergon Energy documents:

- ME000301R104 EMF Guideline for New Infrastructure
- SS-1-1.4 Substation Design Requirements Section 7.1

SES Software (CDEGS) is the Ergon Energy software tool used by Designers for EMF Modelling.

The Designer should model a number of scenarios when undertaking EMF analysis for substations. These scenarios should include:

- Substation Normal Operating Configuration, i.e. apply feeder and transformer loads to represent the normal operating condition of the substation as if all plant is in service.
- Substation Emergency Operating Configuration, i.e. apply worst case feeder and main bus load which may include the main bus supplying the substation load plus the transfer load of up to two additional substations. The model should also include the scenario when a transformer is out of service and the remaining transformer/s are loaded to the continuous overload capacity of 120% of transformer full load rating. The worst case for these scenarios is to apply the loads to the feeders and transformers that are closest to the substation boundaries.
- Substation Ultimate Configuration – Normal Operating
- Substation Ultimate Configuration – Emergency Operating

The Designer must consider and model all sources of magnetic fields in the substation including the incoming and outgoing feeders (overhead lines and underground cables), outdoor busbars and flexible connections, busbars in indoor switchboards, and air cored reactors including inrush and tuning reactors for capacitor banks.

An EMF Report must be developed for all new substation installations. The EMF Report will include, but not be limited to:

- Objectives of the Report
- Introduction including location and features of the substation configuration

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- Development of the EMF Model, including any assumptions
- Reference EMF Levels applied
- Modelling Results, including CDEGS plots of the electric fields and magnetic fields for each scenario
- Summary of Results and any recommended EMF Mitigation required in the Design

The EMF Report must be stored in the EDMS against the substation asset identifier, and checked and approved as per the design approval process.

10.4 Noise

Ergon Energy has an obligation to minimise noise disruption to communities and the environment due to substations. It is mandatory in the design of substation to comply with legislations and regulations and to minimise noise that could lead to prosecutions or fines.

Noise planning and implementation considerations, recommended acceptance noise levels, and relevant publications are detailed in the following Ergon Energy standards:

- SS-1-10.1 Standard for Audible Noise
- SS-1-1.4 Substation Design Requirements

Cadna Software is the Ergon Energy software tool used by Designers for noise modelling. A list of software parameters that a Designer would typically need to apply in the software is included in ANNEX G – NOISE CADNA SOFTWARE PARAMETER TABLE.

The Designer must consider and model all noise sources in the substation including the power transformers, reactors, and building air conditioning.

The Designer should model a number of scenarios when undertaking noise analysis for substations. These scenarios should include:

- Substation Transformer Loading to represent the normal operating condition of the substation as if all transformers are in service.
- Substation Transformer Outage Configuration where only a single transformer is in service and is fully loaded.

A Noise Report must be developed for all new substation installations. The Noise Report will include, but not be limited to:

- Objectives of the Report
- Introduction including location and features of the substation configuration
- Reference Noise Criteria applied
- Results and analysis from Ambient Noise Survey
- Substation Noise Sources
- Development of the noise model and any assumptions
- Modelling Results, including plots of the electric fields and magnetic fields for each scenario
- Summary of Results and any recommended Noise Mitigation required in the design

The noise report must be stored in the EDMS against the substation asset identifier, and checked and approved as per the design approval process.

10.5 Oil Pollution

The Designer must ensure that all substation plant with an oil volume which exceeds the minimum volume as specified in the Ergon Energy standard, or in environmentally sensitive areas must have

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an oil containment and separation system to prevent oily discharge in the event of equipment failure or an oil spill incident.

Oil containment and separation requirements and relevant publications are detailed in the following standards:

- SS-1-9.2 Oil Containment
- SS-1-6.1 Civil Works
- SS-1-1.4 Substation Design Requirements
- AS1940 Clause 5.8 Storage and Handling of Flammable and Combustible Liquids
- AS2067 Substations and High Voltage Installations exceeding 1kV AC

These standards detail the following requirements:

- Minimum size of plant that requires oil containment
- Bunding requirements
- Drainage system
- Oil/water separator system, including ppm output requirements
- Temporary installations
- Transformers in storage
- Environmental risk assessment
- Construction requirements and materials
- G1 separation distance in AS2067 specifies the required distances between the bund wall and the transformer

The type of oil separation system is determined by Ergon Energy Environmental Group and will be determined by the size and location of the transformer and the risk to the environment.

Ergon Energy uses three types of oil separator:

- U-Tube – refer Ergon Energy drawing EESS-10175 U-Tube Oils
- E-Gow – certified by the University of New South Wales
- SPEL Oil Separator

Maintenance of oil separators must be defined as part of the design and must be passed onto the end user. Signage on how to check and maintain separators must be erected on the site.

Reports, Tests or Certificates must be provided for proprietary systems such as the SPEL Oil Separator. Nitrile rings must be used instead of rubber seals in concrete and FRC pipes where hot oil may flow down the pipe. Rubber will expand when in contact with the hot oil and may cause damage to the pipe.

10.6 Visual Amenity

The Designer must ensure that all care is taken to design the substation to be compatible with its surroundings, and that local residents, and the communities expectations are managed where practical. Some of the measures that a Designer may include in the Substation Design to minimise visual impact include:-

- Vegetation buffers around substation perimeter
- Vegetation screening
- Timber and/or architectural security fencing

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- Restricting heights of substation equipment or minimising the number of high masts/structures where practical
- Addition of architectural features and colour schemes to substation buildings
- Indoor Gas Insulated Switchgear

Further design considerations for the planning and the implementation of substations can be found in SS-1-1.4 Substation Design Requirements.

10.7 Plant Pollution Ratings

The external insulation of high voltage plant and equipment must be assessed against contamination severity when pollution is present.

To cater for the majority of installed equipment locations within the Ergon Energy network, the specific insulation creepage distance for all outdoor substation plant and equipment must be a minimum pollution level of Level III – Heavy (25mm/kV) in accordance with Ergon Energy standard SS-1-1.4 Substation Design Requirements and AS 4436 – Guide for the Selection of Insulators in respect of Polluted Conditions.

Where a higher pollution level is encountered, the Designer must ensure that all plant meets the specific insulation creepage distance required of the site, which may mean the procurement of a non-standard plant item. Examples could include plant and equipment at sites subjected to conductive dust deposits, eg from coal handling/processing plants, or at sites located very close to coastal areas and subjected to sea spray.

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11. CIVIL WORKS

11.1 General

This section is a guide for Designers on how to comply with the minimum Civil Works Standards required by Ergon Energy for design inside or immediately adjacent to electrical substations. It includes the design of new and upgrade of existing substations. The Designer must comply with all the requirements defined in this document.

11.2 Civil Design

Civil design includes but is not limited to Earthworks, Stormwater Drainage, Structures, Footings, Buildings, Bunds, Hydraulics, Roadworks, Oil/Water Separation and Fences. All civil design must comply with the latest editions (including amendments) of the following documents:

- The project documents
- SS-1-6.1 Civil Works – sets out the majority of the requirements for civil design and construction.
- SS-1-1.4 Substation Design Requirements
- SS-1-1.8 Standard for Climatic and Seismic Conditions – sets out requirements for climatic conditions including but not limited to Wind, Earthquake, Flood, Fire and Ventilation. These loads must be combined in accordance with AS/NZS 1170 part 0.
  - Wind Loads - A business decision has been made that Region C is to be adopted throughout Queensland regardless of location. This decision has been adopted to minimise costs by only having one standard. The only exception for this rule is when assessing existing structures
  - Flood Levels - The Q200 flood level has been determined from the Guideline for State Planning Policy 1/03 on “Mitigating the adverse impact of flood, bushfire and landslide” - Appendix 9.
- The referenced Australian Standards and Codes
- Statutory and Local Government Regulations and By-Laws
- All sections of this document

All works must be designed for maintenance free lives as detailed in the below table:

Structures	50 Years
Concrete Works	50 Years
Drainage works (occasional clean out of gully pits, traps, and Oil Separator excepted)	50 Years
Pavement Works	25 Years
Bitumen Seal	15 Years
Fencing	25 Years

All works must be constructible and consideration must be given to the ease of construction.

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Proposed Safe Work Area, Builders Storage Areas and Staging must be nominated on the plan. Where outages are required to complete the works, the outage must be negotiated with the Ergon Energy Project Manager

All inspection and testing requirements must be nominated in the project specification. Standard Geotechnical testing requirements for Earthworks and Roadworks are outlined in Ergon Energy Standard SS-1-6.1 - Civil Works.

The Designer must allow too complete as built drawings and upload them into EDMS. Refer to SS-1-6.1 Civil Works and section 9.9 of this manual.

Settlement and deflection tolerances in buildings and yard structures must be considered in substations. Specifically differential settlement between structures is critical when designing. For example, rigid bus bars will have less tolerance for movement than slack strung bus.

The design calculations, drawings and safety in design report for all of the works must be submitted to the Superintendent prior to the commencement of construction. The drawings must be in sufficient detail to unambiguously construct and maintain the works.

11.2.1 Geotechnical Report

All civil design must be based off a thorough geotechnical investigation specific to the site by a registered Geotechnical Engineer. A check of the suitability of existing geotechnical information should be carried out prior to conducting a new investigation. As geotechnical work within substations can be restrictive and costly a full geotechnical investigation is usually carried out to assist in the design of future works. All Geotechnical Reports must be loaded into the EDMS with 'GEOTECH' in the title.

11.2.2 Survey

All civil design levels and set out must be based off a survey by a Registered Surveyor. For existing substations with yard stone the contour survey of existing yard must be of Ground Level not Stone Level to determine surface drainage. All Survey must be loaded into the EDMS with "SURVEY" in the title.

11.2.3 Electrical Conduits, Cable Ducts and Earthing

All design must be in accordance with the following documents:

- The project documents
- SS-1-4.4 Substations Cables and Cabling
- SS-1-7.1 Earthing Standard
- SS-1-6.1 Civil Works Standard

Design of all electrical conduits, cable ducts and earthing must be co-ordinated between Electrical and Civil Designers. Electrical designers must design:

- all conduits and cable ducts
- all earthing requirements
- trench details including standard depths
- thermal backfill requirements
- conduit and cable paths in consultation with the civil designer

Civil designers must design:

- cable ducts and covers
- check electrical covers for structural integrity

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- check constructability of electrical details
- check for clashes with other services and structures

11.2.4 Retrofitting or Replacing Existing Infrastructure

Typically, only the component being replaced and its associated fixing needs to comply with the current Ergon and Australian Standards. For example: Only the roof sheet and associated fixing needs to be to the current standard when replacing the roof cladding on a building. Purlins certified by a previous standard do not require re-certification. This may vary from project to project and from asset to asset depending on the importance of asset and the particular circumstances. Consequently, the project documents and the relevant standards and manuals must be read for clarification.

11.2.5 Replacing High Voltage Substation Plant

The existing structure and footing must be assessed if HV plant and equipment requires replacement. Assessment must be carried out by a registered RPEQ Structural Engineer for compliance with the Ergon Energy and Australian Standards. Supplementary members or footings, spacers and adaptor plates are typical solutions for existing structures and equipment. Where re-use of the structure cannot be justified, a new footing and structure must be used. Refer to SS-1-6.1 Civil Works for standard footing and structure details.

On occasion it may not be possible to access the footing due to lack of information (for example: no footing drawings). In this instance the footing needs to be replaced or Asset Management must provide written approval that the structure can be used based on the advice and risk assessment carried out by the structural and electrical engineers. The following is a list of information required to assess the existing footing and structure

- Geotechnical Report
- General Arrangement
- Equipment Bay Elevations
- Existing Footing Drawing
- Existing Structure Drawing
- Existing Equipment Drawing – including weight
- New Equipment Drawing – including weight
- New clearance requirements
- New conduit and earthing requirements
- New phase spacing
- Height restrictions for spacers
- Photo’s
- Preferred solution

11.3 Site Selection

Guidance on site selection for potential substations including risks and hazards to avoid can be found in the following documents:

- SS-1-1.4 Substation Design Requirements - Section 25 Site Selection
- SS-1-1.8 Standard for Climatic and Seismic Conditions - Table 1 Related Climatic Requirements – Fire and Altitude Requirements

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- SS-1-7.1 Substation Earthing – Section 5.1.3 Soil Resistivity – Testing Requirements
- SS-1.9.1 Substation Fire & Explosion Protection – Section 5.1 Substation Site Considerations- Considerations for vehicle access and fire breaks and provisions for fire fighting

Minimum requirements for the geotechnical investigation are outlined in the Ergon Energy Standard SS-1-1.4 Substation Design Requirements under Section 25 - Purchase Commitment. Site specific tests determined by an experienced Civil Engineer must be included in the investigation.

Contaminated Sites such as old garbage dumps or sites with existing services such as sewer and water mains crossing the property will not be considered for use as substations.

Where required on acquired sites, bulk earthworks and fences must be constructed to ensure material change of use conditions do not expire. Typically Capital Works Signage is required on all acquired sites. Templates for Capital Works Signage are created by the Print Services Department of Ergon Energy. Print Services can be contacted on email - print@ergon.com.au

To order a sign the following information is required:

- Delivery person and location
- Work order / cost centre
- Wording that is to appear; substation name and text, eg. Providing power for a growing Townsville

The size and details for these signs are as follows:

- Size: 2400mm x 800mm
- Material: UV protected, metal, hole punched corners, rounded corners
- Rounded corners @ 40mm Radius
- Holes punched @ 10mm Diameter

Print Services will organise the artwork and initial job specs, then the Procurement & Logistics Department liaise with the suppliers and organise printing and despatch.

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12. CONTROL AND SWITCHGEAR BUILDING

12.1 General

The type of control building required for the project (ie. modular or bricks/blocks and mortar) will be specified in the Project Scope Statement.

The electrical designers must provide the following building layout drawings for use by the building designers.

- Equipment Layout (switchgear, panels, batteries, chargers, doors, air conditioners, furniture, etc)
- Lighting and Power Layout
- Fire and Communication Services Layout
- Cable Ladder Layout
- Earthing Layout

The certified building footing design must be provided by the building Designer with the Civil Design group responsible for ensuring that a Geotechnical Report for the substation site is available to the building designer.

The building layout design must include the provision of a toilet and basin. Alternatively, a separate building may be used to provide those amenities, if more suited to the required equipment layout in the building.

The detailed civil requirements for the building(s), including all necessary freshwater, drainage, and sewerage will be included in the project civil Specification (where provided), plus the civil design drawings.

The control building must include the following furniture :

- Plan desk and chair
- Drawing hanger for storage of substation drawings
- Cupboard(s) for storage of spare equipment, HV operating equipment, earth sticks, etc.
- Shadow board(s) as required for mounting of equipment operating handles, etc.
- Two drawer filing cabinet (to fit under desk).

12.2 Control Building Electrical Services

The electrical services includes building lighting and power circuits, air conditioning, fire protection and security systems.

All design and materials supplied must comply with the requirements of the latest addition of the SAA Wiring rules (AS 3000) and amendments thereto, the Queensland Electrical Safety Act and Regulations, other relevant SAA Codes and the relevant Ergon Energy Standards.

The supplies to the building electrical circuits must be indicated on the substation AC Distribution Board drawings. Refer to Section 16.1 of this Manual for details.

All light switches and GPO's must be flush mounted on blockwork, except outlets of 63A capacity or greater rating (single or three phase) may be surface mounted. Where blockwork is required to be core filled, electrical conduits must be installed into flush mounted wall boxes, to allow drawing in of cables after core filling.

The final electrical installation must ensure that the loads are as evenly balanced as possible across the three phase supply.

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Equipment Manuals provided by equipment suppliers must include full operating instructions, as constructed drawings, test results, manufacturer's product data and safety instructions for the safe installation and use of the equipment.

The air-conditioning system must be designed and provided in accordance with the requirements of Clause 21.4 of SS-1-1.4 Substation Design Requirements, the relevant SAA Codes and other relevant Regulations and the project specification.

A fire protection system must be provided in accordance with SS-1-9.1 Substation Fire Protection, the Work Health and Safety Act and Regulations, the appropriate Australian Standards referenced in SS-1-9.1 and the Project Specification. The system must include a Fire Indicator Panel (including manual call point), detectors, cables, conduits, accessories and fire extinguishers, as indicated generally on the following drawings:

EESS-10181-10 Z6-32D Control Building +2 Fire and communications Services Layout

EESS-10181-11 Z6-32D Control Building +1 Fire and communications Services Layout.

The Fire Indicator Panel must be approved by the Insurance Council of Australia.

A plastic laminated 'as installed' Location diagram of the complete installation must be provided to be mounted on the wall adjacent to the Fire Indicator Panel. The Location diagram must use symbols that comply with AS 1670 and Handbook AS HB20 and must indicate the position of the fire indicator panel, detectors, alarm groups and alarm zone circuit numbers. A complete circuit diagram indicating all wiring and terminal connection details of the output contacts for alarm and/or control purposes, plus details of provisions for future connection of the panel for system monitoring by the Fire Brigade are also required.

The fire protection system must include an air conditioning shutdown signal from the Fire Indication Panel to the relevant circuit on the AC Distribution Board, in the event of a fire. Fire extinguishers must be mounted securely on suitable brackets, enabling ready access to the extinguishers if required, with appropriate identification signs in accordance with the Regulations and located as indicated on the design drawings.

A building security system, including Intruder Alarm Panel where required, must be provided in accordance with the project specification, SS-1-9.5 Substation Physical Security and Monitoring and the relevant Standards and Regulations.

12.3 Locks, Keys, Operating Equipment

Building locks must be flush mounting types, suitable for Ergon Energy's master key system.

Locks must be constructed and located on equipment so that they remain serviceable in the whole range of Queensland climatic conditions for an indefinite lifetime, including continuous periods of up to two years without operation or maintenance.

Building entry & internal door lock barrels must be capable of being replaced by the appropriate Ergon lock barrels, according to the substation region, as this will be done on completion of construction (or earlier if any part of the site becomes subject to Ergon's HVIA procedures, due to the possibility of being made live).

Panel, cubicle and miscellaneous equipment keys, equipment operating handles and the like must be hung on a shadow board(s) mounted in the control building, in the same room(s) as the associated equipment.

Operating equipment such as portable earthing devices (PED's), HV test sticks, DNOB's, HV gloves, etc must be neatly stored in an efficient manner that ensures the equipment remains in serviceable condition and is readily accessible when required. PED's must be hung neatly and singly on smoothly curved brackets of sufficiently generous radius to prevent kinking of conductors or pressure points on the insulation due to prolonged hanging.

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Space needs to be provided either in the control building, or in an external operating equipment shed, as determined most suitable during design for the effective storage of the above operating equipment. Space also needs to be provided in the switchboard room for the efficient parking of circuit breaker trolleys, so as to be readily accessible, but clear of personnel access paths.

Switching padlocks, door lock barrels and operating equipment as listed above are available as Ergon Energy stores stock. Quantities and voltage/current ratings as appropriate, must be determined during design and be included on the Bill of Materials.

12.4 Battery Ventilation

For the situation where substation DC batteries are required to be installed in the control room, they must be housed in fully enclosed cabinets, to prevent release of any evolved hydrogen into the air-conditioning system circulation. As VRLA batteries release a small amount of hydrogen and more so under conditions of heavy charging or battery fault, the battery enclosures must be suitably vented from the top directly to the outside of the building. An air inlet is required near floor level at the front of the enclosure, to provide for movement of air into and up through the enclosure to assist with battery cooling and exhausting of hydrogen to the outside atmosphere. Refer to AS2676.2 and Ergon Substation Standard SS-1-5.1 DC Supplies for ventilation sizing requirements.

Natural ventilation is preferred for simplicity, so as to avoid the need for flameproof fans & monitoring alarms. However, with natural ventilation, consideration needs to be given to the possibility of condensation forming on the inside of the battery enclosure, due to moist outside air from the vent descending and coming into contact with the relatively cold sides of the battery enclosure. In North Queensland particularly, very high humidity levels at or near 100% are experienced throughout the summer months and sometimes extending into the other seasons.

Possible options to consider are (i) thermally insulating the inside of the battery cabinet to prevent contact between the moist air and the cold walls of the enclosure (ii) installing the batteries in a separate battery room with no connection to the air-conditioning system circulation.

Refer also to Section 16.2 of this Manual for further details of DC systems.

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13. PRIMARY PLANT

13.1 Layout

The layout of a substation, referred to as the General Arrangement, must consider:-

a) Access to plant/equipment for installation and maintenance,

b) Adequate safe horizontal and vertical working distances,

c) Adequate clearance for servicing vehicles,

d) Separation distance between fire origin plant/equipment to buildings and fire victims,

e) Suitable for Mobile Substation,

f) Suitable for future extension,

g) Meet aesthetic requirements,

h) Environmental compliance.

The switchyard bay spacing and HV plant separation distances for greenfield substations, and new switchgear bay extensions to existing substations, must be in accordance with the Ergon Energy substation standard drawings and Ergon Energy standard SS-1-3.1 Clearances in Air, Table 2 - Bay and Busbar Spacings.

For 132kV Bay and Plant spacings, refer:

913703-02 Z1-63 Zone Substation 132/22kV Substation General Arrangement

For 66kV Bay and Plant spacings refer:

913703-02 Z6-32 Zone Substation 66/11kV General Arrangement.

The location of underground cables must be clearly indicated on substation underground services and cable route drawings. Cross sections showing cable arrangement must be detailed on cable trench section drawings. In order to minimise induced voltages, cable ducts and cable runs must, wherever possible, be designed to be a right angles to the HV busbars. Where parallel runs are unavoidable, the multicore cables must be separated from the busbars by as large a distance as practicable.

13.2 Plant Ratings

The requirements for the ratings of substation primary plant and equipment including power transformers, circuit breakers, disconnecting switches, earthing switches, current transformers, voltage transformers, indoor switchgear, surge arresters, insulators, rigid busbars, bare conductors and insulated HV cables are specified in the Ergon Energy Standard SS-1-4.1 Primary Plant Ratings.

The Designer must ensure the plant ratings for all project plant and equipment meet the specified requirements in the Project Scope Statement. Any deviations to the standard plant and equipment ratings which are not specifically stated in the Project Scope Statement must be approved by the Project Sponsor.

13.3 Power Transformers

Power transformers used on Ergon Energy's network are purchased from period contract and are listed in ANNEX B – PERIOD CONTRACT PLANT, with the design parameters for the transformer specified in the Project Scope Statement. These parameters must as a minimum include:

- Voltage ratio

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- Rated power
- Insulation Levels
- System Neutral Earthing (Effective / Non-effective)
- Vector Group
- Winding Terminations (Cable / bushing)
- On Load Tap Changer requirements including tapping range and tapping steps
- Specification for HV & LV Current Transformers
- Transformer Impedance

The power transformer and associated components (OLTC, bushings etc) and the connected high voltage cables and/or conductors must be designed to meet the required continuous current and emergency current ratings. The substation transformer Emergency Cyclic Capacity (Long Term Emergency Rating) is normally 125% of rated transformer current, and Short Term Emergency Capacity (Two Hour Emergency Capacity) is normally 150% of rated transformer current.

All new transformer installations and upgrades to existing installations must meet the environmental requirements for the management and containment of the oil as detailed in Section 10.5 of this manual.

The automatic control of transformer tapchangers (OLTC AVR Control) for all new installations must be undertaken through the substation RTU system in accordance with Ergon Energy standard SS-2-3.12 OLTC AVR Control. It is not permissible to install dedicated Automatic Voltage Regulating (AVR) relays.

All transformer functionality, including protection tripping, controls, alarms, and indications must be designed and installed in accordance with the Ergon Energy standard drawings and SS-2-3.1 SCADA Standard Points List.

For an example of a standard substation transformer installation, refer to:

- EESS-10303-01 to -15 Standard ZSS Template =TX01 66/11kV Transformer

Brownfield Site Considerations

When replacing power transformers in existing substations, the Designer must take into account the following design considerations:

- Footing must be assessed in accordance with section 11.2.5 of this manual
- If there is an existing bund, then the Designer must check the bund oil containment volume is adequate for the replacement transformer. The bund dimensions must also be checked to ensure compliance with the replacement transformers oil spill angles.
- The existing lightning protection scheme must be checked against dimensions of replacement transformer to ensure adequate coverage. Consideration should be given to the replacement of any existing overhead earth wires above transformer with a lightning mast if economical and in consultation with the project sponsor.
- If the replacement transformer is required to operate in parallel with an existing transformer which has a different electrical specification, then the Designer must consider any differences in tapping steps and transformer impedances to ensure appropriate sharing of connected loads and minimisation of transformer neutral circulating currents. It is permissible to design the parallel operation of transformers to run at different tap steps with the control algorithm in the RTU adjusted accordingly. The Designer must calculate the optimum tap difference over the full tapping range, and advise the SCADA Designer in consultation with Operations Control group and Protection group. An appropriate notation must be included on the Substation Single Line Diagram Operating in this instance.
- Any existing dedicated AVR relays must be removed and replaced with transformer tapchanger control implemented in the substation SCADA system.

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Control cables between the transformer control box and the substation protection and control panels should be replaced in accordance with the ZSS template drawings. The exception to this is if existing control cables are in accordance with the current control cable standard and have sufficient length to terminate in new transformer control box without intermediate junction boxes, or substantial construction work would be required to replace the control cables.

13.4 HV Circuit Breakers (Outdoor)

High voltage outdoor circuit breakers used on Ergon Energy's network must be from the current Period Contract and are listed in ANNEX B – PERIOD CONTRACT PLANT. If a special, non-standard installation is required to suit existing substation installations, e.g. to meet fault levels, pollution ratings, space restrictions etc., then this must be approved by Ergon Energy Substation Standards Group before proceeding with design and procurement.

When specifying a high voltage circuit breaker from period contract items, the Designer must select the following:

- Control voltage
- Motor voltage

Note: All Greenfield installations must use 110VDC for motor voltage and 110VDC for the control voltage.

- Current transformers for dead tank circuit breakers

Brownfield Site Considerations

When replacing high voltage circuit breakers in existing substations, the Designer must take into account the following design considerations:

- Footing and structure must be assessed in accordance with Section 11.2.5 of this manual
- If the circuit breaker to be replaced has high voltage CTs mounted on the CB structure, then the replacement circuit breaker design must include design for a new high voltage CT installation including footings. It is not permissible to retrofit high voltage CTs to new circuit breaker structures.

Control cables between the circuit breaker control box and the substation protection and control panels should be replaced in accordance with the ZSS template drawings. The exception to this is if existing control cables are in accordance with the current control cable standard and have sufficient length to terminate in new control box without intermediate junction boxes, or substantial construction work would be required to replace the control cables.

All circuit breaker functionality, including controls, status, alarms, and trip circuit monitoring must be designed and installed in accordance with the Ergon Energy SS-2-3.1 SCADA Standard Points List. If the associated protection relays do not have the capability for trip circuit monitoring, the design must include termination of this circuitry in the protection and control panel for future use.

13.5 Current Transformers, Including CT Marshalling Box

High voltage current transformers used on Ergon Energy's network must be from the current period contract and are listed in ANNEX B – PERIOD CONTRACT PLANT. If a special, non-standard installation is required to suit existing substation installations, e.g. to meet fault levels, match existing CT performance or ratios, pollution ratings, space restrictions etc., then this must be approved by Ergon Energy Substation Standards Group before proceeding with design and procurement.

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When specifying a high voltage current transformer from period contract items, the Designer must select the following:-

- number of secondary cores
- primary rated current
- secondary rated current
- turns ratio for each core
- number, core position, performance, and ratios of metering core/s

The Designer must consult with both the Protection and Metering Groups on the suitability of the replacement current transformer to match existing protection schemes, match existing phases if only replacing one phase, and to comply with latest metering Standards.

The designer must consider the total burden when specifying a CT. For protection installations, the following load information may be assumed to determine the rated burdens for CT's:

Total Connected Burden 1A CT	1.2Ω (Loop)
Total Connected Burden 5A CT	0.6Ω (Loop)
Cable Resistance 2.5mm^2	7.41Ω/km
Cable Resistance 4.0mm2	4.61Ω/km
Transformer Protection	200mΩ (phase only)
Line Protection	300mΩ (phase + earth)
Distribution Feeder Protection	600mΩ (phase + earth + SEF, or 2 x phase + SEF)

The standard CT polarity convention is that the P1 terminal is installed on the bus side. This polarity must be shown on the Single Line Diagram Protection and Metering.

CT Marshalling Boxes

A CT secondary marshalling box must be provided for each three phase set of CT's. The marshalling box must be made of either stainless steel or aluminium. The construction and layout of internally mounted equipment must be in accordance with the Substation Standards.

The marshalling box must also have a rotating handle, not a key type access mechanism. The secondary terminals of all CT cores must be connected by multicore cables to the terminals in the marshalling box. These cables must be a minimum of 8 cores with primary & secondary protection cores in different cables. Temporary earths must be made for each 3 phase set of CT cores in the marshalling box. This provision should take the form of a suitable link type terminal block with plug-in feature with the temporary earth connected to the cubicle earth bar.

Refer to EESS-10224-01 to -06 Stainless Steel CT Marshalling Box

Brownfield Site Considerations

When replacing high voltage current transformers in existing substations, the Designer must take into account the following design considerations:

(a) Replacing Three Phases of a CT Installation

- It is often more economical to replace the support structure with a new standard structure, rather than carrying out modifications to the existing structure.
- Footing and structure must be assessed in accordance with Section 11.2.5 of this manual

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- A new CT marshalling box in accordance with the current ZSS Drawings must be installed. The exceptions to this replacement are:
  - if the physical condition of the existing box is still satisfactory and internal space permits, then a new fit-out can be undertaken. The marshalling box fit-out must be in accordance with the current ZSS Drawings.
  - if the existing marshalling box is used for the marshalling of other related bay circuitry and considerable design and construction would be required.
- Control cables between the current transformer and the current transformer marshalling box must be replaced in accordance with the ZSS Template Drawings.
- Control cables between the current transformer marshalling box and the substation protection and control panels should be replaced in accordance with the ZSS Template Drawings. The exception to this is if existing control cables are in accordance with the current Control Cable Standard and have sufficient length to terminate in new control box without intermediate junction boxes, or substantial construction work would be required to replace the control cables.

(b) Replacing two phases of a CT Installation

If the project scope is requiring only two phases of a CT Installation to be replaced, then the Designer should question the validity of this scope with the Project Manager, Project Sponsor and Asset Manager as it can be more economical and prudent to replace all three phases.

(c) Replacing only one phase of a CT Installation

- Footing and structure must be assessed in accordance with Section 11.2.5 of this manual
- The existing marshalling box may be re-used. There must be adequate space in the existing marshalling box to ensure the termination of all new CT secondary cores. There is no requirement to upgrade the existing CT cores secondary wiring, including the installation of CT links to current standards.
- Control cables between the current transformer and the current transformer marshalling box must be replaced in accordance with the ZSS Template Drawings.

(d) Relay compensation

When retro fitting transformer differential protection relays that were externally compensated (e.g. delta connected line CT's), the CT circuits must be reconfigured to Star connected and compensation undertaken in the differential relay. This includes the removal of interposing CT's required for the compensation.

13.6 Voltage Transformers, Including VT Marshalling Box

High voltage inductive or capacitive voltage transformers used on Ergon Energy's network must be from the current Period Contract and are listed in ANNEX B – PERIOD CONTRACT PLANT. If a special, non-standard installation is required to suit existing substation installations, e.g. to meet fault levels, VT accuracy class, pollution ratings, space restrictions etc., then this must be approved by Ergon Energy Substation Standards Group before proceeding with design and procurement.

When specifying a voltage transformer from period contract items, the Designer must select the following:

- Inductive or Capacitive type (for 66kV units only)

Current Period Contract has IVT for 36kV and below and CVT for 123kV and above, and both types are available at 72.5kV. The preference is that IVTs be used for 66kV installations due to a

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physical smaller size and weight. The CVTs are required if the installation requires Type 1 revenue metering where both secondary windings require a 0.2M accuracy class.

When CVTs are installed, a CVT monitor must be included as part of the secondary systems design. Refer to Section 15.10 for details.

VT Marshalling Boxes

A VT secondary marshalling box must be provided for each three phase set of VT's. The marshalling box must be made of either stainless steel or aluminium. The construction and layout of internally mounted equipment must be in accordance with the Substation Standards.

The marshalling box must also have a rotating handle, not a key type access mechanism.

The secondary terminals of all VT secondary windings must be connected by a 4 core control cable to the terminals in the marshalling box.

Refer to EESS-10225-01 to -06 Stainless Steel VT Marshalling Box

VT Secondary Fusing and Earthing

- VT secondary circuits must be fused in the VT marshalling box. The VT terminal boxes must not contain any fuses.
- Each VT secondary winding must be fused in each of A, B, C phases and for the star connected windings, a link must be provided in the neutral using a fuse holder and copper link.
- Similarly a single phase VT secondary winding must be fused on the "a2" side and provided with a link on the "a1" side.
- All fuses and links must be clearly labelled with the circuit function and fuse size or 'Link' as appropriate.
- Where appropriate, warning labels must be fitted to fuses and links e.g. Distance Protection - Do Not Remove.
- The secondary circuits of all VT's including auxiliary VT's must be earthed. Any disturbance to the connections must not at any time allow the VT to be unearthed. The earth connection must be made as close as possible to the VT's, with only one earth connection in each circuit.
- In general the earthing must be by means of a solid connection between the earth bar and neutral. The following earth connections must be made:
  - Three phase voltage transformer circuits have their neutral terminals earthed at the VT marshalling box. The connection is made between the VT side of the link and the earth bar.
  - Single phase VT's earthed at the "a1" ends of their secondary windings at the VT marshalling box.
  - Open delta connected VT's earthed at the terminal corresponding to the C end of the A-C winding. The connection is made between the VT side of the link and the earth bar in the relay panel.

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Brownfield Site Considerations

When replacing voltage transformers in existing substations, the Designer must take into account the following design considerations:

(a) Replacing Three Phases of a VT Installation

- It is often more economical to replace the support structure with a new standard structure, rather than carrying out modifications to the existing structure.
- Footing and structure must be assessed in accordance with Section 11.2.5 of this manual

- A new VT marshalling box in accordance with the current ZSS Drawings must be installed. The exceptions to this replacement are:
  - if the physical condition of the existing box is still satisfactory and internal space permits, then a new fit-out can be undertaken. The marshalling box fit-out must be in accordance with the current ZSS Drawings.
  - if the existing marshalling box is used for the marshalling of other related bay circuitry and considerable design and construction would be required.
- Control cables between the voltage transformer and the voltage transformer marshalling box must be replaced in accordance with the ZSS Template Drawings.
- Control cables between the voltage transformer marshalling box and the substation protection and control panels should be replaced in accordance with the ZSS Template Drawings. The exception to this is if existing control cables are in accordance with the current Control Cable Standard and have sufficient length to terminate in new control box without intermediate junction boxes, or substantial construction work would be required to replace the control cables.

(b) Replacing Two Phases of a VT Installation

If the project scope is requiring only two phases of a VT Installation to be replaced, then the Designer should question the validity of this scope with the Project Manager, Project Sponsor and Asset Manager as it can be more economical and prudent to replace all three phases.

(c) Replacing Only One Phase of a VT Installation

- Footing and structure must be assessed in accordance with Section 11.2.5 of this manual
- The existing marshalling box may be re-used. There must be adequate space in the existing marshalling box to ensure the termination of all new VT secondary cores. There is no requirement to upgrade the existing VT cores, including the installation of secondary VT fuses to current Standards.
- Control cables between the voltage transformer and the voltage transformer marshalling box must be replaced in accordance with the ZSS Template Drawings.

13.7 Disconnectors and Earthing Switches

High voltage disconnectors and earthing switches used on Ergon Energy's network must be from the current Period Contract and are listed in ANNEX B – PERIOD CONTRACT PLANT. If a special, non-standard installation is required to suit existing substation installations, e.g. to meet fault levels, bus heights, phase spacing, pollution ratings, etc., then this must be approved by Ergon Energy Substation Standards Group before proceeding with design and procurement.

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When specifying a disconnector from Period Contract items, the Designer must select the following:

- Manual or Motorised Operation (only disconnectors rated 145kV and above have a motorised option. The use of these disconnectors is non-standard and should only be for special cases as requested by operations or in the design scope)
- Structure Height (Low bus or high bus)
- Earth Switch placement (None, left hand side, right hand side, or both). The convention for the specification of the earth switch placement is when viewing the disconnector from the operating handle side, the earth switch will be on the left or right side.

There is no operational requirement within Ergon Energy to provide interlocking between disconnectors and associated circuit breaker. All earth switches that are integral to the disconnector must be mechanically interlocked with the disconnector.

All new Greenfield substations and new switchgear bay extensions to existing substations must include provision for the disconnector and earth switch status indication to SCADA.

Brownfield Site Considerations

When replacing or installing new disconnectors in existing substations, the Designer must take into account the following design considerations:

- Footing and structure must be assessed in accordance with Section 11.2.5 of this manual
- If adaptor steelwork is utilised for existing footings, then the Designer must ensure that any additional height to the operating mechanism must still enable a person to open or close the equipment with ease while standing at ground level.
- To maintain existing phase spacing and/or bus heights, the Designer should give consideration to using HV flexible connections when retro-fitting disconnectors to existing rigid bus. The preference is to avoid modifications to the standard disconnector assemblies, and where such modifications to phase spacing or height are required then this must be to the Disconnector Manufacturers approval.
- There is no requirement to install disconnector and earth switch status indication to SCADA for retrofits of disconnector and earth switches into a brownfield substation. The exception to this is if status cabling already exists, or is an operational requirement as outlined in the project scope, or a complete new switchgear bay is being augmented.

13.8 HV Switchboards

High voltage switchboards used on Ergon Energy's network must be from the current Period Contract and are listed in ANNEX B – PERIOD CONTRACT PLANT.

When specifying a switchboard from period contract items, the Designer must select the following:

- Configuration of switchboard, including the position and required number of incomer, feeder, and bus section circuit breakers, bus earthing, bus risers and VTs. The configuration for all greenfield projects must be in accordance with the Ergon Energy Standard Substation SLDs.
- Incomer and Bus Section Current rating, (2500A for 20MVA/32MVA substations, 1250A for 10MVA substations)
- Arc Venting requirements
- Control voltage
- Motor voltage

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Note: All Greenfield installations must use 110VDC for motor voltage and 110VDC for the control voltage.

- Current transformers for incomer, feeder, and bus section circuit breakers

The switchroom must be designed to meet the specific requirements of the switchboard manufacturer and the relevant standards (AS62271.200) including:

a. A means of routing the power cables from transformers and to distribution feeders from the switchboard into underground trenches without exceeding the limit of bending radius specified by the cable manufacturer.

b. Room venting facilities to relieve pressure from a switchboard explosion. The position of the arc tunnels and associated pressure relief vents must be located to prevent a safety hazard to the public or personnel working in the substation. All parts that must be examined or adjusted or tested during operation must be arranged well away from internal arc fault vents on top of the switchboards.

c. Floor capable of carrying the switchboard weight without undue deflection, and having a high degree of flatness as required by the switchboard manufacturer specification.

d. Unrestricted working access to the interior of the switchboard panels.

e. Hardened floor surface in front of the switchboard to withstand routine movement of the withdrawable circuit breaker truck without suffering surface damage.

Protection relays are not permitted to be installed in the instrument chambers of switchboard circuit breakers. All protection relays must be in separate dedicated protection and control panels installed remote to the switchroom.

Brownfield Site Considerations

When an extension is required to an existing switchboard, it is recommended that baseline electrical testing in the form of partial discharge testing and insulation resistance is undertaken prior to any construction work.

Switchboard busbar extensions generally involve the design, manufacture and installation of a suitable “joggle” (adaptor) panel to match the existing busbar height and position to the new circuit breaker cubicle, and as such it is recommended that this design and supply is undertaken by a switchboard manufacturer.

The switchgear building must be structurally assessed for the new installation, including the footprint and weight of the new cubicles, additional floor and/or wall penetrations for HV and control cabling, and installation of arc venting as required.

Protection and control panels for new circuit breaker extensions to existing switchboards must be installed remote from the switchboard and be in accordance with the Ergon Energy Zone substation standards.

13.9 HV Cables

High voltage power cable design must meet the requirements of the following Standards:

- SS-1-1.4 Substation Design Requirements
- SS-1-4.4 Substation Cables and Cabling
- AS2067 Substations and High Voltage Installations Exceeding 1 kV AC
- Ergon Energy Underground Manual

When designing a HV power cable installation the Designer must also consider the following:

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- The Thermal Resistivity (TR) of the native soil along the cable route must be tested and the thermal performance of the bedding and backfill materials must be known. Testing TR of native soil will determine whether it is suitable to be used as backfill material or imported backfill will be needed. Soil TR testing can be undertaken by Ergon Energy Ratings and Capability Group.
- Current ratings of HV power cables must be determined by using software (eg Cymcap), which is the preferred method, or from cable manufacturers data and hand calculations in accordance with IEC60287. A list of the software parameters for the Cymcap software to meet the Ergon Energy Cable Design Standards is included in ANNEX H – CYMCAP SOFTWARE PARAMETER TABLE.
- Cables must be designed to meet the required continuous current and emergency current ratings. HV power cables must be rated to supply the substation Transformer Emergency Cyclic Capacity (Long Term Emergency Rating) of the transformer, which is normally 125% of rated transformer current, and Short Term Emergency Capacity (Two Hour Emergency Capacity), which is normally 150% of rated transformer current.
- Cables connected to capacitor banks must have a rating of at least 143% of the capacitor bank continuous current to allow for harmonic currents and 1.1 pu overvoltage.
- Cables connected to station services transformers that are piggy-backed off Distribution Feeders must have a rating for the continuous rating of the station services transformer and the short circuit capability rating of the Distribution Feeder.
- All cable screens must be brought out under the termination and bonded to earth in accordance with the Ergon Energy Standard SS-1-4.4 Substation Cables and Cabling. The Designer must ensure that mitigation measures are in place, including the design and installation of voltage limiters, to ensure the voltage on single bonded cable screens does not exceed 25V. For single point bonded cables the earth bond must be at the transformer end for substation transformer cables, and at the distribution feeder pole for distribution exit cables. The cable screen at the unbonded end must be suitably insulated and protected against inadvertent contact during fault conditions.
- The substation designer must liase with the civil design group to ensure the cable route is coordinated with all underground services, and modifications to existing footings, and/or additional building or wall penetrations are assessed and certified.
- The Designer must clearly indicate the cable location on a cable route drawing. This drawing must include all trench section details (including conduit sizes, dimensions, backfill type, backfill compaction, protective covers), design rating data, and cable earth bonding detail.
- The Designer must ensure minimum cable depths for a substation cable trench design are in accordance with Ergon Energy Standard SS-1-4.4 Cables and Cabling which specifies:
  - 800mm for 11kV & 22kV rated cables
  - 900mm for 33kV and above rated cables

  Additional design requirements including backfill, conduit separations, separation to other services, and protective covers can be found in the Ergon Energy Underground Construction Manual.
- The cable trench design and associated cable configuration for single core cables must minimise the EMF.
- HV power cables must be supported and clamped as the cables rise into the control building or onto the transformer, and on the floor or support structures in cable basements or ducts. Cable clamps must be two piece clamp style and manufactured from non-ferrous material. Clamps must be installed at no more than 1.5m intervals to prevent excessive movement under fault conditions.

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- The division of responsibility between SDTaP Substation Design and Distribution Operations design is as follows:
  - Substation Design will design all feeder cable exit trenches and conduits as far as the substation fence, and must take into account the required feeder minimum cable ratings.
  - Distribution Operations Design will design the cable trenches and conduits beyond the substation fence and is responsible for the supply of all feeder cables and terminations to the substation switchboard.

13.10 Busbars and Conductors

High voltage rigid busbar and flexible conductor design must meet the requirements of the following Standards:

- SS-1-3.2 Busbar Design

When designing a HV busbar installation the Designer must consider the following:

- Rigid busbar tube sizes and flexible connection conductor sizes must be selected from the Ergon Energy Standard.
- The high voltage rigid busbar and associated flexible connections must provide for the required current rating, including consideration for Long Term Emergency Rating and Short Term Emergency Capacity.
- For rigid busbar, the mechanical strength of both the busbar and the support insulators must be evaluated as per the Ergon Energy Standard.
- For long sections of rigid busbar, the wind induced vibration must be checked and if required, a damping conductor must be installed inside the tubular busbar in accordance with SS-1-3.2 Busbar Design. The damping conductor should be loosely installed and fixed to the inside of the tubular busbar at one end only.

Brownfield Site Considerations

When extensions are required to existing rigid busbars, the preference is to extend using the tubes as specified in the Standard, unless it is impractical due to excessive on-site fabrication of adaptor flanges etc. If the existing tube size is to be used, then the Designer must ensure that it meets all of the current ratings and mechanical limits in accordance with the Standard.

When adding busbar extensions, and the existing busbar height and phase spacings are not in accordance with the current Standard, then it is permissible to maintain the existing heights and phase spacing so long as the required clearances to the current Standards are maintained, refer Section 13.11. It is preferred that no modifications to standard plant are undertaken to fit the existing busbar installation.

It is permissible to re-use existing flexible conductors and fittings so long as an assessment of the current rating and mechanical condition to satisfy the new installation has been undertaken.

13.11 Clearances

The Designer must ensure all switchyard clearances are compliant with the mandatory distances in Queensland Legislation, Australian Standards and Ergon Energy requirements.

Refer to:

- Queensland Electrical Safety Act 2002
- AS2067 Substations and High Voltage Installations Exceeding 1 kV AC
- S-1-3.1 Clearances in Air

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All Greenfield substations and where possible, new bay extensions to existing substations must use the standard spacings between items of switchyard plant as depicted on the ZSS General Arrangement Drawings.

Refer to:

- 913703-02, -03, -04, -05 Z1-63 General Arrangement and Elevations
- 913303-02, -03, -04, -05 Z6-32 General Arrangement and Elevations

Brownfield Site Considerations

When retro-fitting new substation plant into Brownfield substations, it may not be possible to maintain the switchyard clearances as specified in the Ergon Energy Standard or the Queensland Electrical Safety Act.

The mandatory distances that shall be maintained are the section, horizontal, and vertical clearances, as specified in AS2067.

The Qld Electrical Safety Act provides additional clearance above the non-flashover distance as specified in AS2067, and is known as the Exclusion Zone. If the design cannot meet the required clearances using the exclusion zone, then it must meet the requirements of AS2067. In this instance a risk assessment must be undertaken and documented as part of the Safety in Design process, refer to Section 5.4.3.

Example: An 11kV switchyard originally designed to AS2067 will have section clearance of 2615mm (Ground 2440mm +Non-flashover 175mm). Designing new plant in accordance with the Safety Act will require a section clearance of 3140mm, an increase of 525mm. If the switchgear cannot be practically installed to meet this increased clearance, then it is acceptable to use the 2615mm clearance and undertake an appropriate risk assessment.

13.12 Lightning and Surge Protection

Shielding against direct lightning strike must be provided for all substation installations. The lightning shielding system must be designed in accordance with Ergon Energy Standards. Refer to:

- SS-1-1.4 Substation Design Requirements
- SS-1-8.2 Substation Direct Lightning Strike Shielding

The use of overhead earthwires to provide shielding above switchyard busbars and HV plant must be avoided.

Surge protection must be incorporated into the design of all substations to ensure that all plant and equipment is protected from lightning strike, all sources of power system surges, and GPR. Refer to:

- SS-1-1.4 Substation Design Requirements
- SS-1-8.1 Substation Surge Protection
- SS-1-8.3 Selection of Surge Arresters
- SS-1.8.4 Insulation Coordination

Surge Arresters for substation applications must be of Metal Oxide Construction, and a minimum Class 3 Energy Capability. All arresters must have an insulated base fitted, and earthing connections installed in accordance with Ergon Energy Standard Earthing to facilitate the measurement of on-line leakage current measurement. There is no requirement to install surge counters on substation surge arrester installations. Refer to EESS-10031-17 Surge Arrester Earthing Assembly and EESS-10031-55 Surge Arrester Test Connection.

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14. EARTHING

Substation Earthing Design must meet the requirements of the following Standards:

- SS-1-1.4 Substation Design Requirements
- SS-1-7.1 Substation Earthing
- SS-1-7.2 Safety Earthing
- AS2067 Substations and High Voltage Installations Exceeding 1 kV AC
- IEEE Std 80

Where conflict arises in these Standards, the Designer must select the more onerous requirement in the design.

14.1 Main Earth Grid

SES Software (CDEGS) is the Ergon Energy software tool used by Designers for the design of substation main earth grids. A list of software parameters that a Designer would typically need to apply in the software is included in ANNEX F – CDEGS SOFTWARE PARAMETER TABLES.

When designing a substation main earth grid, the Designer must consider the following:

- Prospective Future Fault Level for the Substation. The highest prospective fault could be a single-phase to earth or double-phase to earth fault current with consideration to future augmentation, additional circuits and/or transformer capacity at the substation. This data can be obtained from the Fault Summaries document available from the System Development Group.
- Worst Case Protection Clearing Times. The selected clearing times must include all backup clearing times, and must be selected in consultation with the Protection Group. In accordance with Ergon Energy Standard SS-1-7.1 Substation Earthing, two design clearing times must be considered in the design of the main earth grid, the first for the calculation of the earthing conductor size, and the second for the calculation of the permissible step and touch voltages.
- Soil resistivity data must be obtained from field measurements. The Wenner test configuration is the preferred measurement method.
- The connection of OHEWs and high voltage cable screens to the substation grid can reduce the level of fault current passing into the main earth grid, and hence will lower the Ground Potential Rise (GPR) and prospective step and touch potentials. As an accurate analysis of this fault current split between the earth grid and outgoing shielding wires and cable screens is not always achievable, the Designer in the first instance should exclude these current splits from the model, and assume all fault current will pass through the main earth grid.
- The general layout and positioning of the main grid conductors must ensure a practical and economical design to ensure that all substation areas satisfy the prospective step and touch potential safety criteria, and allows for two grid riser connections to each item of HV plant without unnecessary riser lengths.
- Due to the multiple parallel conductor current paths, the main earth grid conductor is sized to carry 70% of the prospective future fault current for the worst case protection clearing time. Two earth grid risers are required to be connected for each item of HV plant and each earth grid riser must be sized to carry the full fault current.
- The Designer must analyse a number of scenarios when undertaking an earth grid design for substations. This analysis should include:
  - Determine worst case fault current and protection clearing times scenarios for all voltage levels present at the substation. A bus fault on the LV side of the substation transformer or a

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very close in-line fault on the distribution network may not create a significant GPR, therefore the Designer must evaluate the worst case fault current to give the maximum GPR.

- For each scenario, calculate the prospective step and touch voltages for an Electrical Worker or Contractor, and the General Public. For these calculations, a 70kg body weight can be used for workers inside the substation, and a 50kg body weight must be used for the calculation of prospective step and touch voltages outside the substation fence.
- A surface insulating layer consisting of 100mm depth of crushed rock with a nominal diameter of 20-30mm and a nominal electrical resistivity of 3000 ohm/m should be used inside the substation fence to increase the maximum allowable safe voltage limits.
- Other shock hazard mitigation techniques should be considered before using an insulating layer outside the fence due to the expense and the installation in an uncontrolled environment (using a 50mm bitumen layer is more controlled and preferred over crushed rock outside the fence). These techniques may include further reduction in earth grid impedance, reduction in fault current by analysing current split factors to OHEW and cable screens, adjusting protection to minimise fault clearing times, installation of barriers and isolation/insulating panels. If these mitigation options are not practical or feasible, then the Designer may use the probabilistic method to quantify the risk and design to an ALARP Principle. Guidance on the ALARP Principles can be found in the Ergon and Industry Standards. Refer to:
  - SS-1-7.1 Substation Earthing
  - Energy Networks Association EG-0 Power System Earthing Guide
- The Designer must also identify for each scenario any other shock hazard locations and shock magnitude, including transferred voltages, voltages from magnetic field induction, and electric field coupling, e.g. transfer of potential to nearby fences, buildings, metallic pipelines etc.

- The Designer must document as part of the Safety in Design Documentation all risks and associated control measures identified in the Substation Earthing Design, in particular those identified in an ALARP Analysis. Refer Safety in Design section 5.4.3 of this manual.

All buried earth grid conductors must have adequate corrosion protection, in particular when the backfill material has a pH < 6.0 or pH > 10.0. or the soil has an electrical resistivity < 10 ohm.m Refer to SS-1-7.1 Substation Earthing for conductor backfill requirements.

All below ground earth grid conductor joints, including crimps and welds, must meet the requirements of IEEE Standard 837 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding, and only approved propriety compression connectors that passed the IEEE 837 tests must be used.

The Standard Assembly and Construction Practices for earthing of all substation HV plant and equipment is detailed in the ZSS Earthing Drawings. Refer to EESS-10031-01 to 55 Earthing

The Designer must include in the Earthing Design the provision of attachment points for the installation of Portable Earthing Devices (PEDs). Refer to SS-1-7.2 Safety Earthing. The design of the attachment points must meet the requirements and style of the PEDs in use at the substation. The location of the PED attachment points must be shown on the Substation General Arrangement Drawings.

14.2 Secondary Earthing and Bonding

All protection and control panels, AC and DC systems, LV power, control and instrumentation cables, cable trays and ladders, and sundry metalwork in the building must be connected to the main earth grid. Refer to Ergon Energy standard SS-1-7.1 Substation Earthing and AS3000 Wiring Rules. Additional requirements are detailed below.

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- All metallic cases of instruments, control switches, relays etc, mounted on control panels or in cubicles, must be effectively earthed to the nearest earth bar with stranded copper green/yellow insulated conductors of not less than 2.5mm^2.
- All LV power cables (except for building lighting and power circuits to AS 3000) must have double brass tape screens with both ends of the screens bonded to earth via a suitable earth bar. Earthing conductors for power cable screens must be stranded, green/yellow insulated copper of minimum cross sectional area of 2.5 mm^2.
- All multicore control cables must have double brass tape screens with both ends of the screens bonded to earth via a suitable earth bar. Earthing conductors for control cable screens must be stranded, green/yellow insulated copper of minimum cross sectional area of 2.5 mm^2.
- The earth bars in each individual protection/control, AC Systems, DC Systems and other panels must be connected to the main earth bar using a conductor of equivalent cross sectional area to the main earth bar. The main earth bar is typically installed in the overhead or under floor cable tray.. The common earthing conductor which provides the main earth bar may be either stranded, green/yellow insulated, copper conductor of minimum cross sectional area of 70mm^2 laid in and regularly bonded to the cable tray, or tinned copper strap with minimum cross section of 25mm x 2.5mm, regularly bolted to the cable tray.
- All separate sections of cable tray must be bonded by a continuous earth bar, with the earth bar connected to the main earth grid at a minimum of two connection points, one from either end of the cable tray. For very long cable trays/ladders additional connections to the earthing system should be provided.
- All control building metalwork, including door and window frames, roof, metal trusses etc must be directly connected to the main earth grid and not connected via any equipment earthing, eg cable tray main earth bars. Bonding conductors for the building metalwork may be either stranded, green/yellow insulated, copper conductor of minimum cross sectional area of 35mm^2, or bare copper strap with minimum cross section of 25mm x 2.5mm.
- The Designer must provide suitable drawings showing the earthing arrangement and earthing connections of the building and the building equipment.

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15. SECONDARY SYSTEMS

15.1 Protection and Control Panels

Standard cubicles are available as period contract items through the Ergon Energy store and must be used for all new greenfield projects, and wherever possible retro-fitted into existing substations. These cubicles have a maximum 48U of mounting space and consist of two types being either rear entry or swing frame. Refer to:

- EESS-10240-01: 48RU Front Access Cubicle Layout
- EESS-10241-01: 45/48RU Rear Access Cubicle Layout

When designing the layout of panels the following guidelines should be adopted:

- Protection cubicles must have the X (or Main) protection mounted in the top of the panel and the Y (or Backup) protection in the bottom of the panel. Switchgear control and indications must be mounted in the centre of the panel.
- The Designer must ensure each of the segregated protection functions includes all components, e.g. fuses, links, relays, test facilities, and terminals in order to facilitate maintenance and future upgrading of the panel. Spare blanking plates to a maximum of 5U (including the relay) should be allowed above the protection relays to allow for future upgrades.
- Protection signalling relays, if used, should be mounted adjacent to the protection relay they are associated with.
- It is preferable that 4U at the bottom of the panel be a blanking plate to allow more convenient safe access to panel equipment for wiring and maintenance.
- It is required that no relays with interface screens (i.e. LCDs) be mounted higher than 2000 mm (preferably 1800 mm) from the bottom of the panel. This implies that there is a minimum of 5U between any smart relay and the top of the panel. If required, auxiliary relays or relays with little operator interface should be mounted above the smart relays to achieve this.
- Panel mounted white NS links, orientated vertically, should be used for trip isolation links. The intention is that all CB fail initiate or protection signalling functions that leave or enter a panel have separate isolation (this is not required on every panel they pass through i.e. one only isolation per function). Panel mounted black fuses should be used for DC supply isolation and VT secondary circuit isolation (where required).
- The Substation Standards philosophy is to provide facility on the protection panels for emergency control in the event of RTU/SCADA failure. Protection relays should not be used for circuit breaker control functions (excluding auto-reclose). In order to provide a common operator interface that will provide control in the event of SCADA failure, equipment control (e.g. CB trip/close, SEF enable/disable, auto-reclose enable/disable, work clearance on/off) must be provided by discrete control switches mounted on a panel in between the Main and Backup sections. There is no requirement for Transformer tapchanger controls (such as master/follower, auto/manual) to be included on the control and protection panels, with these functions being performed in the RTU/SCADA only.
- When positioning panels in the control building, the clearance to the rear of the panel is preferred to be 1200 mm, (minimum 1000 mm), and the clearance to the front of the panel is preferred to be 1500 mm, (minimum 1200 mm).

  In accordance with AS2067, “aisles shall be at least 750mm wide”, and “space for evacuation shall always be at least 600mm, even when removable parts or open doors, which are blocked in the direction of escape, intrude into the escape routes”. “So as not to hinder escape, the doors of switchgear cubicles or bays should where possible close in the direction of egress”.

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- All panels should provide adequate lighting, vermin control, ventilation, and a barrier to prevent inadvertent contact with live terminals or inadvertent access to the wrong panel in a suite.
- For the purpose of insulation and safety, exposed studs on fuses and links should be avoided. This maybe by using fuses with recessed entry, a separate sub-frame with connections via a terminal rail, or insulated guarding.
- A suitable earth bar is required in each panel
- Test facilities in the form of a CT and VT test link rack for each group of relays should be located immediately below the protection relays to which they are associated with. As well as CT and VT secondaries, the test facility should include a DC bus +ve and –ve as well as relay digital outputs in accordance with the protection application guides. Trips and CB fail circuitry must not be wired to the test facility. The design of the panel must ensure that all routine testing can be performed from the front of the panel via the test facility provided.

  The standard test facility consists of panel mounted SAKC10/T1 terminals.

  Refer to EESS-10246-01 19" Rack Mounting Plate 3U Test Terminal Rack
- The standard wiring convention for fuses and links is as follows:
  - For CT and VT test links the wiring from the CT or VT is connected to the top of the link and the relay is connected to the bottom. This convention ensures that applied CT shorting leads are above the test instrument leads and hence are not in the way when reconnecting test leads. The exception to this is ESAA metering test blocks, where the CT shorts are integral to the test block and are on the bottom of the links, hence the wiring from the CT (and also VT) must be connected to the bottom of the link.
  - For supply fuses and links, the positive and negative supply side is connected to the bottom of the fuse or link and the panel is connected to the top. This is considered an "industry standard", provides consistency with manufacturers of MCB's etc., and provides fuse protection for accidental contact from falling objects on to live rear terminal studs.
  - For trip isolation and initiating links, the relay contact initiating the trip is connected to the bottom of the link and the item being operated (CB trip coil, multi trip relay, or initiated protection relay) is connected to the top of the link. This convention is consistent with the CT and VT test links in that the field (or outgoing panel) wiring is on the top side of the link, with the connected test instruments on the bottom of the link.

Brownfield Site Considerations

The following guidelines should be used when replacing protection relays in existing substations.

- If a single relay is to be replaced on an existing panel, the new installation should as a minimum include the new relay and a standard test link rack. Consideration should also be given to installing a new fuse/link rack. New AC and DC schematics must be produced in accordance with the latest template drawings.
- If a protection upgrade is required on an existing panel which requires both main and backup protection to be replaced, then consideration should be given to either "re-skinning" the panel with a 19" rack frame, or where possible a new protection panel installed.

15.2 Protection Relays

The protection design must be in accordance with the Project Scope Statement and meet the requirements of SS-1-1.4 Substation Design Requirements and SS-2-2.1 Substation Standard Protection.

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15.2.1 Relay Selection

The protection schemes and relays to be used are detailed in the Project Scope Statement for the project. The Designer must ensure the design incorporates all of the protection functions included in the Project Scope Statement and will operate correctly and safely.

All relays used on Ergon Energy's network must be from the current Ergon Energy period contract and are listed in ANNEX C – PERIOD CONTRACT PROTECTION RELAYS. At times it may be necessary to direct purchase relays to suit specific brownfield requirements. This will be on a case by case basis, and preference must be given to using a current period contract protection relay. If it is deemed a specific non contract relay is required, then this must be selected in consultation with the Protection Group.

To provide diversity and to minimise any common mode failures from relays supplied from the same manufacturer, the period contract provides relays of the same function but from different manufacturers. The Designer must ensure that main and backup protection relay schemes (or X & Y schemes) utilise relays from different manufacturers. Refer ANNEX D – RELAY SELECTION.

15.2.2 Protection Application Guides

The Protection Application Guides (PAG's) are a suite of controlled drawings in the EDMS which specify the standard application for each protection relay. Sheet 01 of the guide details the panel cut-outs, AC current and voltage connections, DC supply connections, and standard allocation of digital I/O for the intended application. Sheet 02 of the guide details the relay device functions and the DNP mapping for SCADA.

All designs that require the installation of new protection relays must be undertaken in accordance with the relay configuration as detailed in the PAG. The Designer must not deviate from the PAG even if the same functionality is provided, i.e. change I/O allocation, as the Protection Group have developed standard setting files based on the PAG. Where a protection application guide is not available or not suitable the Operational Technology Team must be contacted at the design stage.

Refer to ANNEX E – PROTECTION APPLICATION GUIDES for a list of the Protection Application Guides.

Brownfield Site Considerations

For existing substation installations it may be necessary to alter the standard relay configuration to match existing protection philosophy and circuitry. These alterations may include but are not limited to, the use of additional I/O, using the standard I/O for a different function, and changes to the AC connections. If an alteration is required to the standard protection application, the Designer must consult with the Protection Group.

15.3 Trip Circuits

Protection relay contacts used for tripping, indication, or alarm must be of robust and reliable construction. All contacts must be clean and have appropriate current ratings to match the required duty.

Where relays/systems do not provide adequate facilities or ratings to trip all required devices, tripping must be achieved by auxiliary trip relays initiated from the individual protection relays/systems.

Separate tripping relays must be provided for transformer protection schemes and bus protection schemes. These relays must have latching contacts that can be reset locally and remotely via SCADA.

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All other tripping relays must have self-reset contacts and continuously rated operating coils.

Operation indicators must be provided on the transformer and bus protection systems trip relays but are not required on trip relays used for contact reproduction. Flags or LEDs are equally acceptable and must be reset by the same system that resets the contacts.

The design of the operation and isolation of trip circuits for all new circuit breakers, and where available on existing brownfield circuit breakers, must ensure the following:

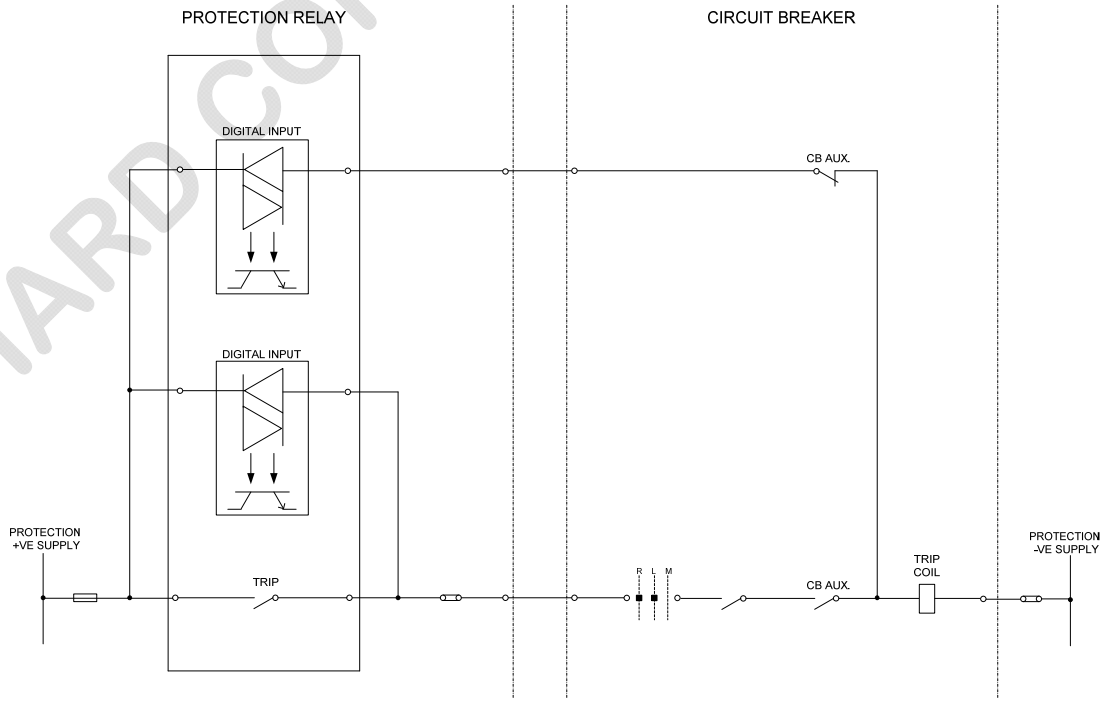
Trip Function	**Circuit Breaker Local / Off / Remote Switch Position**
Main Protection	Local and Remote
Backup Protection	Local and Remote
SCADA Trip	Remote
Protection/Control Panel Manual Pushbutton or Switch	Remote
Circuit Breaker Local Trip	Local
All trip circuits to the trip coil must be disconnected when switch is in Off position	

Control trips via SCADA or manual push buttons/switches must be hard-wired directly to the trip coil circuit, and not via protection relays. i.e. It is **not** permissible to utilise serial communications between the SCADA and the protection relay for circuit breaker control tripping.

When main and backup protection supplies and trip coils are available, the manual control trips must be wired to the backup trip coil circuit.

Trip Circuit Supervision (TCS) circuitry must be designed and included for all circuit breakers in new Greenfield Substations. Both main and backup coils must be monitored in the circuit breaker closed and open states. TCS is implemented in the main and backup protection relays in accordance with the Standard Template Drawings and Protection Application Guides. There is no requirement to install additional relays for the purpose of providing trip circuit supervision functions.

A simplified representation of the TCS circuitry is as follows:



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TCS circuitry for brownfield applications must be included as part of protection upgrade works, provided the existing circuit breaker has the required circuitry, or can easily be modified to include the required TCS circuitry for each trip coil. If the circuit breaker cannot be wired to provide the required TCS circuits, then the TCS circuits must be wired from the protection relay to the protection panel terminal blocks for future installation.

15.4 Close Circuits

Protection relay contacts used for circuit breaker closing must be of robust and reliable construction. All contacts must be clean and have appropriate current ratings to match the required duty.

Where relays/systems do not provide adequate facilities or ratings to close all required devices, closing must be achieved by auxiliary close relays.

All closing relays must have self-reset contacts and continuously rated operating coils.

The design of the operation and isolation of close circuits for all new circuit breakers, and where available on existing brownfield circuit breakers, must ensure the following:

Close Function	Circuit Breaker Local / Off / Remote Switch Position
Auto Reclose from Protection Relay	Remote
Auto Reclose from SCADA	Remote
SCADA Close	Remote
Protection/Control Panel Manual Pushbutton or Switch	Remote
Circuit Breaker Local Close	Local
All close circuits to the close coil must be disconnected when switch is in Off position	

Control close via SCADA or manual push buttons/switches must be hard-wired directly to the close coil circuit, and not via protection relays. i.e. It is **not** permissible to utilise serial communications between the SCADA and the protection relay for circuit breaker control closing.

When main and backup protection supplies are available, the manual control close must be wired to the backup supply circuit.

There is no requirement to provide supervision of the close coil circuits.

Capacitor bank circuit breakers must have a close inhibit to allow for capacitor bank discharge. This scheme is best implemented by utilising the capacitor bank protection relay to perform the timing function which is initiated from the CB status. The protection relay is required to have a close inhibit output contact placed in the signal path to the circuit breaker close coil and is best positioned in the close coil negative to ensure all sources of the closing signal are inhibited, i.e. from SCADA, control panel, and local at circuit breaker.

15.5 Auto Reclosing

The preferred method for the design and implementation of auto-reclosing (A/R) of substation circuit breakers is to utilise the protection relay logic. If the protection relays are not capable of providing an auto-reclose function, then an alternative is to use the substation SCADA system. The installation of dedicated auto-reclose relays is **not** permitted.

There is no requirement to include auto-reclosing blocking schemes for bus protection and transformer faults. Application of the standard relay circuitry will ensure an auto-reclose initiate signal is not present for these faults.

When designing an auto-reclose scheme the Designer must include:

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- For protection schemes with main and backup relays, only one relay is required to perform the auto-reclose function. The backup protection relay is the preferred relay to implement auto-reclose control logic
- The main protection relay must provide a hard-wired auto-reclose initiate signal to the backup protection relay.
- Auto-reclose control and indication must be provided for each relay that is performing an auto-reclose function. The standard enable/disable control is to provide an illuminated, momentary pushbutton as a digital input to the protection relay. A digital output from the relay is used to power the pushbutton lamp.
- An auto-reclose block auxiliary contact from the enable/disable switch is not required in the circuit breaker closing circuit.
- A live line work clearance control switch must be provided for each relay that is performing an auto-reclose function. The functionality of this switch is to ensure auto-reclose logic in the protection relay cannot be enabled, and when required, to change the relay settings for faster clearing times. The standard work clearance on/off control is to provide an illuminated, momentary pushbutton as a digital input to the protection relay. A digital output from the relay is used to power the pushbutton lamp.
- A work clearance block auxiliary contact from the on/off switch is not required in the circuit breaker closing circuit.
- Remote auto-reclose enable/disable control, work clearance on/off control, and the associated status indications must be provided from the substation SCADA system, with the preferred method being via DNP serial communications to the relay.

The ZSS template drawings for feeder protection, includes all the required auto-reclose functionality.

For 66kV Feeder Auto-Reclose refer to:

- EESS-10301-01 66kV Feeder Panel Equipment Layout
- EESS-10301-04 66kV Feeder CB Protection & Control DC Wiring Schematic
- EESS-10301-05 66kV Feeder Main Protection DC Wiring Schematic
- EESS-10301-06 66kV Feeder Backup Protection DC Wiring Schematic

For 11kV Feeder Auto-Reclose refer to:

- EESS-10306-01 11kV Feeder Panel Equipment Layout
- EESS-10306-04 11kV Feeder CB Protection & Control Wiring Schematic
- EESS-10306-05 11kV Feeder Protection DC Wiring Schematic

Brownfield Site Considerations

If the backup protection relay is not capable of performing the auto-reclose function, then auto-reclose can be implemented in the main protection relay. In this case, the auto-reclose circuit design must provide the same functionality as if it would be implemented in the backup relay, i.e. backup protection relay would provide the initiate signal to the main protection relay and all auto-reclose controls would be in the main protection relay.

If neither protection relay is capable of providing auto-reclose functions, then consideration must be given to a SCADA auto-reclose implementation. For a SCADA auto-reclose scheme, the protection relay/s are required to provide an auto-reclose initiate/trip output contact to the substation RTU. The RTU provides the auto-reclose signal to the circuit breaker using the same digital output as the circuit breaker control close signal from the RTU. Auto-reclose control functions should include the installation of a magnetically latching bi-stable relay to retain the auto-reclose enable/disable status, with this relay being operated from a panel switch and the RTU enable and disable output contacts. Auto-reclose status should be indicated at the substation panel from an additional RTU output contact, not the latching bi-stable relay. Refer to Ergon Energy SS-2-3.21 Standard for SCADA Auto-Reclose Implementation.

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15.6 Circuit Breaker Fail Protection

Circuit breaker fail (CBF) protection schemes must be designed to isolate a fault that has been detected by other protection but has not cleared. This other protection is said to initiate the CB fail scheme. The basic philosophy for the implementation of CBF protection is a timer and an overcurrent relay, with the timer being initiated by the protection initiating the protection operation. After a time dependant on the expected switch clearing time, (not usually exceeding 200ms), the timer must cause a trip to all other circuit breakers necessary to isolate the fault, only if the overcurrent relay detects fault current still flowing. Isolation of the fault may include a requirement to send an inter-trip signal to a remote end substation.

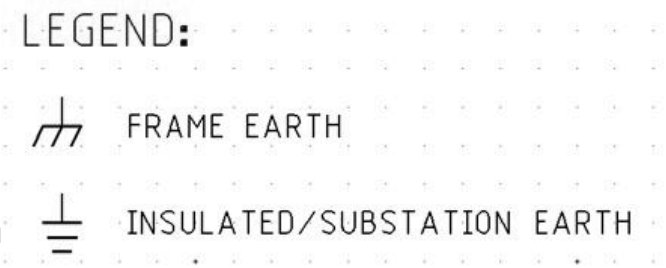
Due to unreliability and sometimes slow operating times, it is **not** permissible to use circuit breaker auxiliary status contacts as a means of detecting the circuit breaker fail event.

For all new greenfield substations, CBF must be integrated within the Main and Backup protection relays, or the feeder management relay for a single scheme protection.

The CBF scheme must be designed such that the scheme is reliably reset if the initiating signal and/or the overcurrent is removed, including a reset if necessary before the intended CBF output eventuates (i.e. for circuit breaker slow opening times). To facilitate this, either the initiating relay signal must reset or the overcurrent check element must reset. It is therefore preferable to **not** use a latching relay to initiate the CBF scheme, as reliance on the reset of the overcurrent check elements only may be longer than the CBF trip time.

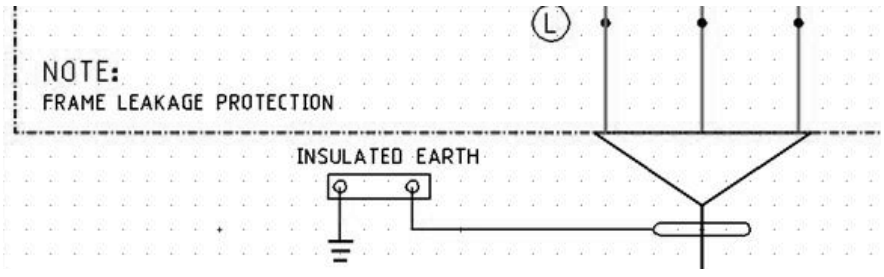
15.7 Frame Leakage Protection

Switchboard frame leakage protection is a very simple efficient protection system but it can easily be defeated or mal-operated by incorrect earth connections. Frame leakage protection is not a current Ergon Energy protection application, and therefore must not be implemented in greenfield sites. Where frame leakage protection is implemented on 11kV and 22kV switchboards at brownfield sites, the SLD's must show the protection zones with a frame earth symbol as follows:



AC schematics must show how the high voltage cable screens are connected to insulated or substation earths. Cable connection diagrams must have notes or details explaining that cable screens must be connected at remote ends only.

Example:



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15.8 Sensitive Earth Fault Protection

Distribution feeder protection schemes must include Sensitive Earth Fault (SEF) protection. For all new protection installations and any upgrades to existing protection, SEF protection is to be implemented in the new protection relay in accordance with the Ergon Energy Standard and ZSS template, hence removing the requirement for a dedicated SEF protection relay.

The SEF scheme must include a transformer neutral check which will inhibit the feeder SEF trip unless transformer neutral current is present. An additional trip output for the purposes of an SEF trip is not required, with the protection relay utilising the main protection trip output contact for this function. As there is no delineation in relay trip output between a protection trip and an SEF trip, the neutral check function is to be provided from a non-latching Multi-trip relay as a digital input to the protection relay performing the SEF, and not as a hard-wired inhibit contact in the tripping circuit.

SEF protection schemes must include control and indication for both remote and local enable/disable of the scheme. Local control will be in the form of a panel pushbutton wired to the protection relay digital input with a corresponding lamp driven from a relay output, and remote control is implemented through the serial communications from the SCADA to the relay.

For implementation of SEF protection, refer to:

- EESS-10310-06 SEF Check Protection DC Wiring Schematic

SEF protection may be required to be implemented on transmission and sub-transmission feeders which supply or traverse mining sites, or any other sites considered a mining installation, eg coal handling plants etc. This requirement must be outlined in the Project Scope Statement for the project. This scheme will be implemented in the backup protection relay with the same functionality as the distribution feeder.

15.9 Underfrequency Protection

Under frequency protection is implemented at the distribution feeder level. For all new protection installations and any upgrades to existing protection, underfrequency protection is to be implemented in the new protection relay, hence removing the requirement for a dedicated underfrequency protection relay.

An additional trip output for the purposes of an underfrequency trip is not required, with the protection relay utilising the main protection trip output contact for this function.

Underfrequency protection schemes must include control and indication for both remote and local enable/disable of the scheme. There is no requirement to provide local control of underfrequency protection at the relay panel, and remote control is implemented through the serial communications from the SCADA to the relay.

15.10 CVT Monitoring

Routine condition assessment testing of Capacitive Voltage Transformers in the form of oil dissolved gas analysis cannot be undertaken due to the hermetically sealed capacitor stacks, and therefore CVT's require additional on-line condition monitoring.

For each CVT installed in a Greenfield Substation, and where required to be retro-fitted to Brownfield Substations, the Designer must include a dedicated, stand-alone CVT monitoring relay in the Secondary Systems Design. The CVT monitoring relay measures the three phase secondary voltage of the CVT and it is preferred to be connected to the backup protection circuit.

The preferred connection to SCADA is DNP serial communications, or a hard-wired alarm output contact where DNP SCADA is not available.

The design for the installation of CVT Monitoring relays must be undertaken in accordance with the Protection Application Guide as listed in ANNEX E – PROTECTION APPLICATION GUIDES.

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15.11 SCADA Systems

Control Systems Design must be in accordance with the project scope and includes all automatic control function requirements (e.g. OLTC AVR Control, Capacitor Control, Auto Reclose), Substation Design Drawings (preliminary SLDs and detail RTU drawings to start the control system design, and then final drawings to check and finalise the control system design) and Protection Relay Configurations (Protection Application Guides and Protection Standards to start the control system design, and then final Protection configuration report to check and finalise the control system design).

Where the project requires the construction and commissioning work to be staged, enough control systems design work is initially done to allow the first stage to be completed with the remain control systems design work done as part of the following stages.

The major components for a substation control system design are the SCADA Master Station, RTU (Remote Terminal Unit) and LCF (Local Control Facility).

15.11.1 SCADA Master Station

The SCADA points and communication configurations are defined by the Ergon Energy Standards SS-2-3.1 SCADA Standard Points List and SS-2-3.2 SCADA Standard Point Naming. The design work for this is performed using the Ergon Energy development tool SSDB.

The SCADA displays are defined by the Ergon Energy Operating Schematic Drawings and the SCADA Display Style Guide. The design work for this is performed using the SCADA Master Station development tool PED500.

All SCADA Master Station Design Work is performed internally by Ergon Energy Control Systems Design group.

For substations that border other electricity entities, SCADA data sharing may be required as defined by the Ergon Energy standard SS-2-3.11 SCADA Points List for ICCP.

For a brown field design, the new bay numbering needs to consider the existing bay numbering defined in the SCADA Master Station to ensure the continuity of data available to the control centre operators.

15.11.2 Remote Terminal Unit (RTU)

The current Ergon Energy standard RTU is the Invensys Foxboro SCD5200. The RTU hardware can be made up of a number of separate RTUs with each RTU comprising various cards. The standard RTU cards used by Ergon Energy are:

- COE (CPU Optonet Ethernet),
- Wide Range Power Supply,
- 8 channel Serial Communications (for serial connections to Intelligent Electronic Devices),
- ADI (Analogue and Digital Inputs),
- DO (Digital Output controls).

For analogue inputs, precision resistors are fitted with a 100 ohm resistor being the standard.

A standard RTU is available from the Ergon Energy stores. Additional RTU cards are to be added as required for the project.

RTUs must obtain supply directly at the Substation DC supply and must have a separately fused DC supply for the COE card and the I/O cards.

The Open / Close controls for the primary plant circuit breakers must be provided directly from the RTU and not via the protection relays. These controls must be performed by utilising momentary action voltage free trip close contacts on the RTU.

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The SCADA points and communication configurations are defined by the Ergon Energy Standards SS-2-3.1 and SS-2-3.2. The design work for this is performed using the Ergon Energy development tool SSDB. RTU configuration files are to be saved on the RTUs (i.e. .cfg, .elf, and .sal files). All RTU configuration design work is performed by Ergon Energy Control Systems Design group.

Automatic control functions must be provided by the RTUs and include OLTC AVR Control (as per SS-2-3.12 a ±20% suppressed zero voltage transducer connected to the VT for the reference voltage), Capacitor Control (as per SS-2-3.10), Auto Reclose Control (as per SS-2-3.21 and only if protection relays are not capable), protection relay resets, analogue conversions, and others as required by the project scope.

The communications medium and protocol between RTUs and other RTUs, IEDs and the SCADA Master Station are defined in SS-2-3.1. The communications medium between the RTU and the SCADA Master Station will be dependent on the project. For a two or more RTU substation, RTU 1 must provide communications to the LCF and remote diagnostic engineering access, and RTU 2 must provide communications to the SCADA Master Station. Where required for a 132/110kV substation, RTU 1 must also provide backup SCADA Master Station communications. The control system and associated communications links must provide sufficient capacity to meet the scan times specified in SS-2-3.1.

Brownfield Site Considerations

Existing commissioned RTU points must not be rewired to alternate RTU points unless absolutely necessary due to the extra control system design and extra commissioning work that would result from this change.

15.11.3 Local Control Facility (LCF)

The LCF hardware is defined in SS-2-3.1 SCADA Standard Points List. The current preferred LCF is the Wonderware touch screen. Other current LCFs include the Uticor touch screen and the Wonderware PC. The LCF must be located to allow close access to telephones, radio communications equipment and a work area suitable for performing switching operations.

The LCF must be provided power supply via the Substation DC system.

The SCADA points are defined by the Ergon Energy Standards SS-2-3.1 and SS-2-3.2. The design work for this is performed using the Ergon Energy development tool SSDB.

The SCADA displays are defined by the Ergon Energy Operating Schematic Drawings and generally by the SCADA Display Style Guide. The design work for this is performed using the LCF manufacturer's configuration software.

The LCF must include remote engineering access interface.

All LCF design work is performed by Ergon Energy Control Systems Design group.

15.12 Communications

15.12.1 Site Classification

The Project Scope Statement for a project should clearly specify the communications classification (e.g. TDM CAN) for a substation site and the required inter-site connection requirements. The detailed design document for that site classification can then be referenced on NocNet to determine the standard communications equipment that is required at that location and the various communications links that can be established for intra/inter site connections. These documents also specify the standard port allocations for the various communications devices to be installed at these sites.

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Refer: NocNet Intranet > Documents - Corenet > Technical Docs > Site Design

The specifications for the standard SDH multiplexers (Alcatel TSS-100 & 1662) used throughout the network can be referenced on NocNet as well. These detailed design documents also contain the standard card configurations for the SDH multiplexer based on the site classification described in the paragraph above.

Refer: NocNet Intranet > Documents - Corenet > Technical Docs > Equipment Design Docs

15.12.2 Standard Drawings

Standard Communications Drawings can be found in the EDMS under the "COMMUNICATIONS STANDARD" asset identifier. The following drawings should be considered (where applicable) as part of a communications design release for a substation project:

- Equipment Layout
- DC Schematic
- Comms Schematic Diagram
- SensorProbe Schematic Diagram
- Main Distribution Frame Diagrams
- Cable Connection Diagram
- Data Cable Connection Diagram
- Cable Schedule/s

15.12.3 Equipment Coding

Each piece of communications equipment installed at a substation site is to be labelled with an Equipment Code (e.g. –U65). These equipment codes can be found in the Equipment Coding spreadsheet located on the pccomms drive. Where this equipment is installed in a communications panel (e.g. YX01) it is to have a dot number following the equipment code (e.g. –U65.1) to uniquely identify the item. This requirement is applicable even if there is only a single device of that type at the site as future projects may install additional devices and this eliminates the need to re-label devices in that event.

Refer: \\etsvds02\pccomms\Drawings\cad_standards

15.12.4 Communications Cabling

Communications cabling installed within substation must comply with the requirements of Sections 11-14 of STMP004: Standard for Communications Equipment Installation and Section 13 of SS-1-1.4: Substation Design Requirements. Refer to:

- STMP004 Standard for Communications Equipment Installation
- SS-1-1.4 Substation Design Requirements

15.12.5 Engineering Access

Engineering access to IEDs within a substation is generally provided via a combination of two different means depending on whether the IED has a suitable Ethernet or serial interface. For an Ethernet equipped device the connection is via the OCN switch at the site whereas for serial devices the connection will be via a Lantronix terminal server.

The OCN switch has standard port allocations which are detailed in the OCN Switch Port Allocations spreadsheet located on the pccomms drive. OCN Drawings produced by the CNOC detailing device connections at substation sites can be found in the EDMS under the "OPERATIONAL COMMUNICATIONS NETWORK" asset identifier.

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Refer: \\etsvds02\pccomms\Documentation\Remote Access\OCN Equipment

The Lantronix Port Allocations spreadsheet on the pccomms drive records the Lantronix port connection details for IEDs within a substation.

Refer: \\etsvds02\pccomms\Documentation\Remote Access

15.12.6 SCADA Communications

The SCADA communications to a substation site will be DNP3.00, connecting the RTUs to the regional ABB RDAS. An IEEE 802.3 10Base-T half duplex interface must be provided via the Operational Communication Network (OCN) to connect to RTU-2. If Sequence of Events (SOE) time-stamping is required for SCADA events then either a GPS clock will need to be installed at the substation or revert to a legacy serial connection as mentioned in Section 6 of the Ergon Energy Telecommunication Requirements v1.0 document.

Refer: NocNet Intranet > Documents - Corenet > Technical Docs > Network Design Docs > Ergon Energy Telecommunication Requirements v1.0

15.12.7 Protection Communications

There are generally two forms of communicating protection schemes – current differential and communicating distance. For current differential the standard interface between the protection relay and PDH multiplexer will be C37.94. For communicating distance schemes the standard interface between the protection relay and PDH multiplexer will be V.24. Where there is an economic/technical advantage C37.94 could be used instead for this circuit by placing a SEL2894 converter on the serial port of the protection relay.

Refer: NocNet Intranet > Documents - Corenet > Technical Docs > Network Design Docs > Ergon Energy Telecommunication Requirements v1.0

15.12.8 Telephony

Where required, a substation control room telephone can be provided using either a subscriber interface on a PDH multiplexer or Telstra landline. If a Telstra landline is used a telephone isolation cubicle will be required in the substation control room to prevent hazardous voltages being induced into the Telstra network. In the future, VOIP will be used.

15.12.9 VHF Mobile Radio

Where required a VHF mobile radio must be provided within the substation control room. The folded dipole antenna will either be mounted on a dedicated communications pole (refer drawings 903384-01 & 903384-02) or fitted to one of the lightning masts within the substation yard. The VHF radio will require a 12VDC negatively earthed supply.

15.12.10 Communications DC Supplies

Where a Communications DC Supply is required at a substation site in accordance with Ergon Energy Standard SS-1-5.1: Substation DC Supplies, Section 16.2 of this document and/or the Project Scope Statement it will generally be designed in accordance with the Ergon Energy Standard SS-1-5.1: Substation DC Supplies.

The capacity and autonomy of the DC system must be determined using the principles of Appendix 1 of the above Standard. Higher autonomy times may be required for remote sites without standby generation and some critical point of presence or backbone sites.

Ergon Energy currently uses a number of Rack Power Systems (RPS) to suit various equipment loads and installation requirements. The specifications/drawings of each of these systems can be found in the EDMS under the “COMMUNICATIONS STANDARD” asset identifier.

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15.12.11 Communications Materials

Details of the common communications assemblies installed at a substation site can be found in the Communications Materials spreadsheet located on the pccomms drive. This spreadsheet also details the applicable stock codes for items held within Ergon Energy Stores or whether items need to be purchased through an external purchase order arrangement.

Refer: \\etsvds02\pccomms\1. TECC\Documentation\Standards\Materials

15.12.12 Operational Support Systems

Ergon Energy uses a number of operational support systems used to document and manage its telecommunications network. These systems include, but are not limited to:

- STRIDE Cable for Managing the Physical Fibre Optic Network.
- STRIDE Mux for Managing the Various Levels of The TDM Network.
- STRIDE IP for Managing the MPLS Core Backbone Network.
- VQSM for Managing Asset and Service Levels.

All Telecommunications System Diagrams, circuit, service and configuration data is to be entered into Ergon Energy's operational support systems as described in the Ergon Energy Corenet High Level Design Document. Refer to STRIDE Mux Operations Manual and Guide, STRIDE Cable Operations Manual and Guide and STRIDE IP Operations Manual and Guide.

Refer to:

- NocNet Intranet > Documents - Corenet > Technical Docs > Network Design Docs
- \\etsvds02\pccomms\Stride_Cable\Guide
- \\etsvds02\pccomms\Stride_Mux\Guide

15.13 Metering

15.13.1 General

The metering design must be in accordance with the Project Scope Statement and meet the requirements of SS-1-1.4 Substation Design Requirements, SS-2-4.1 Metering, and NA000403R328 Queensland Electricity Connection and Metering Manual (QECMM).

Metering in a substation is classified into the following types:

- Panel and SCADA Metering
- Statistical Metering
- Revenue Metering

The Designer must represent all substation metering, including the associated connections to communications and SCADA, on the Single Line Diagrams for the substation.

As an example, the following standard drawings can be referred to:

EESS-10480-03 Z6-32D Zone Substation Single Line Diagram Protection and Metering

EESS-10480-05 Z6-32D Zone Substation Single Line Diagram Revenue Metering

Meter types, mounting details and panel locations, and standard wiring must be as specified in Ergon Energy Standard SS-2-4.1 Metering and the ZSS template drawings.

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For statistical and revenue metering installations (3 phase, 4 wire), the following load information may be assumed to determine the rated burdens for CT's and VT's:

Voltage Circuit	< 3 VA per phase voltage
Current Circuit	< 0.5 VA per current coil
Meter Burden	< 5 VA (Aux Supply with Voltage circuits de-energised)

For transducers, the following load information may be assumed to determine the rated burdens for CT's and VT's:

Active Transducer, Current Circuit	0.5 VA
Active Transducer, Voltage Circuit	1 VA
Active Transducer, Aux Supply	3 VA
Passive Transducer, Current Circuit	1 VA

15.13.2 Panel and SCADA Metering

Panel and SCADA metering equipment includes:

- Protection relays capable of providing analogue quantities to SCADA
- Power quality meters
- Transducers, including those used for the purpose of CVT monitoring
- Analogue/digital panel meters or displays.

For all new substation installations and where protection upgrades are undertaken on existing substations, the panel metering must be provided by the new electronic relays, or by a transducer in accordance with the Zone Substation Standards. The metering quantities provided by the relay to the SCADA will be via serial communications.

Any surplus metering equipment resulting from a redesign or upgrade must be removed from the panels, including its associated wiring, i.e. where a transducer or panel meter is replaced by an electronic relay. It is not permissible to add to, or modify existing substation mimic panels to keep the mimic functional when a new electronic device is installed. Any metering or meter displays on substation mimic panels must also be removed as part of an upgrade.

The required output for all transducers connected to the substation RTU is 0-20mA. Transducers for the purposes of providing transformer tap position indication to the substation RTU are preferred to have a BCD output.

15.13.3 Statistical Metering

Statistical meters must record substation bus voltage and the total substation load, including connected reactive loads, and are therefore required to be installed on the following:

- Incoming Transmission and Sub-transmission feeders
- Substation Transformer LV incoming supplies
- Capacitor banks
- AFLC plant
- SVC's

For all new substation installations, the statistical metering and associated hardware, including ESAA test blocks, and communications modems, must be installed in dedicated metering panels. There is no requirement for statistical metering to comply with Australian Energy Market Operator (AEMO) requirements.

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Statistical meters are to be powered from the substation DC supply including provision for a supply fail alarm to the SCADA. For remote communications access and associated download of metering data, each statistical meter is to be connected to a serial terminal server mounted in the metering panel. The metering terminal server must be connected to the substation OCN switch.

Refer to:

EESS-10312-01 to -06 =QX01 11kV Statistical Metering Panel

EESS-10313-01 to -05 =QX02 66kV Statistical Metering Panel

15.13.4 Revenue Metering

Revenue meters must be installed on the following:

- Substation feeders which directly supply a customer
- Local Supply Metering

For all revenue metering installations, the revenue meters and associated hardware, including ESAA test blocks, and communications modems, must be installed in dedicated metering panels. The revenue metering installation must comply with Australian Energy Market Operator (AEMO) requirements. All meter terminals, fuses, test blocks, marshalling and terminal points for revenue metering must be sealable. Refer to Ergon Energy standard SS-2-4.1 Metering for the requirements and details for sealing arrangements.
Revenue meters are to be powered from the substation DC supply including provision for a supply fail alarm to the SCADA. Communications must be provided for each revenue and check meter for remote communications access and associated download of metering data by the Metering Data Provider. This communications can be via a cable to the substation telephone equipment, or by the installation of a 3G modem and associated antenna. The communication requirements must be approved by the Ergon Energy Metering Services Group.

Refer to:

- EESS-10316-01 to -05 =QX03 11kV Revenue Metering Panel

The substation 415V local supply must be metered for revenue purposes and Network loss calculations. A single local supply meter must be installed at the main switchboard to measure all energy consumed at the switchboard. The local supply meter installation must meet all of the requirements of a revenue metering installation, including remote communications. Additional design information can be found in Section 16.1.4 of this manual.

15.13.5 Metering Voltage Transformers

A Voltage Transformer auto-changeover scheme using voltage selection relays must be installed in the metering panel for all new metering installations where two VTs are available as a suitable meter VT supply. The voltage changeover must be initiated for loss of voltage detection on any phase. The VT changeover output is also used to power the remote communications serial server.

Refer to:

- EESS-10312-03 =QX01 11kV Statistical Metering Voltage Selection AC Wiring Schematic

The VT rated burdens specified are based on estimated loads. The Designer must ensure that the VT's have adequately rated burdens such that the load on each metering winding at rated voltage will lie between 25% and 70% of the winding's rated burden.

Metering VT loads must be balanced on all three phases as far as possible. For any 3 single phase VT installation, the least loaded metering winding must not carry less than 80% of the load experienced by the most heavily loaded metering winding. The Designer must follow manufacturers' installation guides for transducers and meters with respect to metering inputs. VT

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balancing is to be achieved via appropriate assignment of auxiliary supply and single phase metering load. Any shortfall may then be made up with resistors having the appropriate temperature rating, and be connected close to and on the load side of the VT terminals such that the burden measured at the VT terminals will include the effects of the resistive burden. All resistors must be adequately ventilated and mounted so any generated heat does not affect other components.

15.13.6 Metering Current Transformers

The CT rated burdens have been specified on the basis of estimated loads. The Designer must ensure that CTs are rated such that the total burden at rated current on each metering winding lies between 25% and 70% of the winding's rated output.

Each metering core of a 3 phase installation must be loaded to achieve an acceptable balance between phases. The least loaded core must carry not less than 80% of the load experienced by the most heavily loaded metering core. 3Ph, 3w transducers and meters must be wired to the preferred phases indicated in their appropriate installation guides.

Dummy loads may be fitted where necessary, for balancing purposes and to achieve the loadings stipulated above. Dummy loads must be connected close to and on the load side of the CT terminals such that the burden measured at the CT terminals will include the effects of the applied burden.

15.14 LV Cabling, Secondary Wiring and Terminals

The design of secondary wiring, terminals and multicore cables must meet the requirements of SS-1-1.4 Substation Design Requirements, SS-1-4.4 Substation Cables and Cabling and AS3000 Wiring Rules. Additional requirements are detailed below.

- Current ratings of LV power cables must be determined either from using relevant tables in AS/NZS 3008-1.1 or manufacturer's catalogues. The Designer must ensure voltage drop along LV Power and secondary control cabling is allowed for when selecting cable sizes.
- The current rating of Station Services Transformer 415V cabling must be designed for the full load capacity of the Station Services Transformer, not the maximum demand of the substation.
- The minimum conductor cross-sectional area for secondary wiring is:

CT Circuits – Switchyard, Control Panel to CT Marshalling Box	4.0mm^2
CT Circuits – Switchyard, CT Secondary Terminals to CT Marshalling Box	2.5mm^2
CT Circuits – Panel	2.5mm^2
VT Circuits – Switchyard	2.5mm^2
VT Circuits – Panel	2.5mm^2
Control Circuit – Switchyard	2.5mm^2
Control Circuit – Panel	1.5mm^2
Alarm & Indication – Switchyard	1.5mm^2
Alarm & Indication – Panel	1.5mm^2
SCADA Remote Terminal Unit – Analog/Digital Input	0.2mm^2
SCADA Remote Terminal Unit – Digital Output	1.5mm^2
DC Supply (Distribution to Protection Panel)	6.0mm^2

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- LV Power cables must have an orange outer sheath for AC circuits, and a black outer sheath for DC circuits. Control and instrumentation cables must have a black outer sheath. All protection and control panel secondary wiring must be grey with the exception of LV power AC wiring where the phase colouring must be Red, White and Blue for the active phases (R W B), Black for neutral (N) and Green/Yellow for ground (G). The cores of DC power cables must be Red and Black.
- AC and DC circuits must be run in separate cables. Where X and Y protection systems are used, the X and Y secondary circuits must be run in separate cables.
- Cable separation distances between LV AC power cables, control cables and instrumentation cables must be maintained in accordance with SS-1-4.4 Substation Cables and Cabling Sections 6.3 and 6.4.
- All cable runs must be in conduits, cable trays, ladders or cable trenches. Underground cable runs must be in conduits or trenches. It is not permissible to direct bury LV power, control and instrumentation cables, and must not be run in the same ducts or conduits as HV cables.
- Each cable must have a unique identifying number and the cable numbering must be in accordance with Section 3.11 of SS-1-1.2 Substation Equipment Naming Guidelines and the Zone Substation Template drawings. The Designer must ensure all cables are identified on the substation cable schedules. The cable schedules must include the following details:
    - Cable Number
    - Cable Size, Cores and Type
    - Cable Length
    - Destinations (From / To)
    - Purpose

  Refer to: EESS-10320-01 to 25 Zone Substation Cable Schedule
- Each cable core must have an identifying number and the wire numbering must be in accordance with Section 3.12 of SS-1-1.2 Substation Equipment Naming Guidelines and the Zone Substation Template drawings.
- All secondary wiring terminal blocks, fuses etc, must be readily accessible through doors or readily removable plates which do not require the use of tools to open.
- Terminals in 415V and 240V AC circuits must be protected by inherent design features or an insulated cover to protect against inadvertent contact. All such terminals and surrounding barriers must be identified as “415/240V AC” by means of a label with white lettering on a red background, attached to the terminal barriers or covers.

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16. MISCELLANEOUS

16.1 Auxiliary AC Supplies

16.1.1 General

The design of auxiliary AC supplies must meet the requirements of Ergon Energy and Australian Standards.

Refer to:

- SS-1-1.4 Substation Design Requirements
- SS-1-5.2 AC Supplies
- AS 3000 Wiring Rules
- EESS-10314-01 to 09 415V AC Distribution Supply

When designing the Substation Auxiliary AC Supply Systems the Designer must also consider the following:

- The design must include everything necessary for, or usually designed as part of the 415V AC supply system.
- All components must be entirely satisfactory for the service conditions and intended operational requirements, whether such conditions or operational requirements are directly specified or not.

The 415V AC three phase main switchboard and sub-boards must be designed in accordance with Ergon Energy Standard SS-1-5.2 AC Supplies and the ZSS template drawings.

16.1.2 415V AC System Earthing

The supply neutral must be earthed at one point only at any given time. i.e. At the appropriate station supply transformer neutral terminal, or the generator neutral terminal, according to which source is connected to the 415V system at the time. An M.E.N. system must **not** be installed.

16.1.3 AC Changeover Boards, Standard and Sizing

The AC changeover circuitry must be designed and rated in accordance with Ergon Energy Standard SS-1-5.2 AC Supplies and the relevant ZSS drawings. The changeover contactor must be a 4 pole unit, to include switching of the supply neutral, so that the neutrals of the station supply transformers are not paralleled.

16.1.4 AC Supply Metering

(a) The AC supply metering installation must be designed in accordance with the requirements of the Queensland Electricity Connection and Metering Manual (QECMM). Section 9 of QECMM indicates the particular requirements of current transformer metering, including the current transformer chamber opening width and height, minimum and maximum mounting height for the CT secondary terminals and the clearances required around the current transformers, voltage fuses and meters, however it does not specifically indicate a required minimum depth for the current transformer chamber.

(b) It is essential to specify the minimum depth of the CT chamber in the design drawings (as well as the minimum chamber opening width and height), in order to avoid the panel being supplied with too shallow a depth.

The minimum depth required for the current transformer chamber is dictated by the various clearances required, plus equipment dimensions as indicated in items 1 to 4 of the table below.

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Description	Dimension	Reference Drawing in QECMM
1. Inside back of panel to centre line of busbar (defined by CT size)	65mm (CT type S) 85mm (CT type T) 85mm (CT type W)	QECMM-9.3
2. Clearance from plane of busbar to rear of fuse block	75mm minimum	QECMM-9.2
3. Depth of fuse block from front to rear	70mm	QECMM-9.4
4. Clearance from front of fuse block to inside front of panel	25mm minimum	QECMM-9.2
Total minimum CT chamber depth required	**235mm (CT type S)** **255mm (CT type T)** **255mm (CT type W)**	

Given that the requirement for Type S CT's is only 20mm less than that for Type T & W CT's, it is recommended that we aim to standardise on a **minimum depth of 255mm** in all cases if possible.

(c) Drawing ECMM-9.2 in Section 9 of QECMM indicates that the three phase CT's may be mounted either in line across the chamber, or staggered. The staggered arrangement shown in the QECMM Drawing results in the voltage fuses needing to be mounted at the bottom of the chamber, which is likely to be near floor level. It is recommended that the CT staggering be inverted vertically from that shown (i.e. middle phase highest and outer phases lowest), so that the fuses can be mounted near the top of the chamber, as indicated for in-line mounting of the CT's. Ergon Energy Metering Group have indicated verbal agreement with that approach and may amend the QECMM in the future.

(d) The minimum depth for the metering panel will be determined by the depth of the meter from front to back, plus a minimum clearance of 175mm from the front of the meter to the inside of the closed panel door, as required by Clause 9.10 of QECMM.

(e) The metering CT's, fuse blocks, meters and test blocks must be ordered in advance from the Ergon Energy Metering Group by the relevant Design Group. If available early enough, these can be forwarded to the AC panel supplier for installation.

16.1.5 AC Distribution

Following the metering chamber, the selected main AC supply must be connected to a main AC Distribution Busbar via a main isolation switch. The busbar is also supplied from an emergency generator connection, as indicated in section 16.1.7. The fire indication supply must be connected to the incoming supply from the changeover contactor, before the main switch for the AC Distribution Busbar, as required by Clause 7.2 of AS3000.

The AC Distribution Busbar provides the following outgoing supplies through individual circuit breakers:

(a) Essential Supplies Sub-Board for each control building – providing essential supplies for control building and switchyard services.

(b) Non-Essential Supplies Sub-Board for each control building - providing non-essential supplies for control building and switchyard services.

(c) Each separate transformer oil filter 100A outlet. (One outlet only may be sufficient to service both transformers, in some cases dependent on switchyard layout).

(d) AFLC circuit (where required)

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The Essential Supplies Sub-Board in (a) above will provide circuits to transformer, circuit breaker and other equipment control supplies (tap changers, fans, etc.), battery chargers, SCADA Local Control Facility (LCF), control building internal lighting, emergency lighting, control building essential GPO circuit, switchyard lighting, and an essential supply phase failure alarm.

The Non-Essential Supplies Sub-Board in (b) above will provide circuits to switchyard equipment heaters and GPO's, control building GPO's, control building air-conditioners, switchyard 3 phase outlets, and a non-essential phase failure alarm.

16.1.6 Switchyard Outlets

As well as the 100A outlet for the transformer oil filter, a 3 phase 32A outlet must be installed close to each transformer and in the vicinity of the HV rigid busbars. For a very long bus, a 3 phase outlet may be required approximately every 30m.

A 15A single phase outlet must be installed in each substation bay, close to the circuit breaker. Some of these outlets may already be supplied in the circuit breaker and transformer LV cabinets. Where not provided, they must be mounted separately in suitable locations close to the transformer or circuit breaker.

16.1.7 Generator Connections

The emergency supply generator is connected via a manual changeover switch to supply the Essential Sub Boards only. The configuration of the changeover switch circuitry must prevent connection of the generator supply back to the main distribution bus.

Refer: EESS-10314-04 415V AC Distribution Supply Wiring Schematic

During construction of a new substation or in the unlikely event of needing to supply the non-essential sub-boards, oil filter, etc. during a complete substation outage, a larger generator would be needed, which could be connected via cable in place of one of the station supply transformers. This approach enables the emergency generator and associated changeover circuit to be kept to a limited size, thus enabling quicker availability, as well as minimising cost.

16.2 DC Supply Systems

The design of DC supplies must meet the requirements of SS-1-1.4 Substation Design Requirements, SS-1-5.1 DC Supplies and the ZSS template drawings. Additional requirements are detailed below.

There must be either one or two 110V DC supply systems to supply the control and protection circuits for the major plant and ancillary systems within the substation, plus one or two 48V DC supply systems if required, to supply communications and SCADA control equipment. Substation Standard SS-1-5.1 DC Supplies provides guidance as to the number of systems required and whether the 48V DC system is to be provided by DC/DC converters or separate batteries. In some unclear cases, the Project Scope Statement may override the Substation Standard.

This Section describes the general requirements of the batteries, battery chargers, battery stands, DC/DC converters, DC/AC converters, and DC distribution boards for the 110V and 48V DC supply systems.

The design of the DC supply systems must allow for the ultimate development of the substation.

Each system must be a high reliability standby system consisting of a battery bank (each battery bank consists of 2 battery strings in parallel), individual isolation and protection (using Isolation and Test Panels), individual battery charger and DC distribution board. Except where separate 48V DC batteries and chargers are required either by SS-1-5.1 DC Supplies or the Project Scope Statement, DC/DC Converters must be used to supply equipment at DC voltages other than 110V.

All items supplied must be entirely satisfactory for the service conditions and intended operational requirements, whether such conditions or operational requirements are directly specified or not.

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The design must utilise standard equipment sourced from the current period contract for DC systems. Drawings and Specifications of all standard items on the period contract are available.

Design of the DC supply systems includes selection of suitable capacity, layout within control building, allocation of circuits and wiring of all of the following, in accordance with SS-1-5.1 DC Supplies:

- Battery banks
- Battery chargers
- Isolation and test panels
- DC/DC converters
- DC Distribution Boards
- DC/AC inverters (where required)
- All cabling between the components

The Substation Designers will design and supply the 110V DC Supply Systems, including the 110/48V DC/DC converters where required and the Communications Designers will design the 48V DC supply systems.

If a desktop HMI is required for a particular project, then a 110/240V DC/AC inverter must be supplied from a separate circuit breaker on the 110V DC Distribution Board and preferably mounted in that panel. Where both 'X' and 'Y' 110V DC Distribution Boards are required, the inverter should be supplied from the 'Y' 110V DC supply as depicted in Drawing 907199-01.

All exposed 240V AC Terminals, etc. must be separated and shrouded from other wiring to prevent inadvertent contact by personnel, and also identified with the normal 240V AC warning sign.

Inverter GPO's (coloured red) should be installed in a suitable location near the desk, so as to be easily accessible, but sufficiently out of the way to minimise the risk of the HMI being unplugged inadvertently.

Bolts, nuts, washers and inter-connections must be of an inherently corrosion resistant material, or otherwise protected against corrosion in an acceptable manner.

16.3 Lighting

16.3.1 General Requirements

Lighting Design must meet the requirements of Ergon Energy Standard SS-1-1.4 Substation Design Requirements, STNW3040 Standard for Substation Lighting and the ZSS template drawings.

The requirements for illuminance level, glare rating and colour rendering index, spill and skyglow within substation switchyards and buildings are set out in STNW3040.

DC Emergency Lighting must be provided within control and switchgear buildings, to enable safe entry, passage and exit from the building in the event of AC supply failure at night. Design requirements are set out in STNW3040. A wall switch must be provided just inside the control room (and switchgear room where installed in a separate building) to enable the emergency lighting to be enabled or disabled when the normal AC lighting is turned on or off. Alternatively, the emergency lighting can be enabled via motion sensors, if required in a particular substation. The ability to test operation of the emergency lighting via pushbutton or similar must be provided.

External general lighting must be provided under the control building eaves, consisting of weatherproof (IP56) luminares controlled by a movement sensor and switches both inside and outside the control building.

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In addition to the general lighting as specified in STNW3040, PE cell and motion sensor activated security lighting must also be provided. Requirements are as indicated in STNW3040, plus an over-ride switch labelled “Test Switch for external security lights”. The under- eaves lighting in the paragraph above would probably form part of the security lighting.

16.3.2 Design Requirements

In determining the lighting requirements of the switchyard, a full Lighting Study must be carried out, using a software package such as AGI Light, to confirm the lux levels around the substation yard and boundary. The Lighting Study must include a plan view of the switchyard with lux levels shown, details of the type and angle of each light and the location and height of each mast.

Ergon Energy STNW3040 Standard for Substation Lighting indicates the minimum lux levels required in various parts of the switchyard, but manual review and adjustment of the final design should be carried out to avoid any shadow areas at operating points such as circuit breaker control cubicles and disconnector operating handles, so as to assist easy finding and reading of operator nameplates during emergency switching.

The design must also take into account neighbouring residences, buildings, roads, & the sky, etc, so as to avoid excessive light spill into those areas.

16.3.3 Switchyard Lights and Mounting Structures

Switchyard lighting must consist of high quality, energy efficient, weatherproof floodlights, generally located on dedicated lighting poles and switched from inside the building. Floodlights should be installed at 45-60 degrees or other angle required to maximise the effectiveness of the light.

Lighting poles must be hot dipped galvanised and hinged at the base or mid-way up the pole to ensure maintenance is capable of being performed at ground level, without the use of ladders or elevated work platforms. The design must check the swing down or hinged poles as to proximity to HV equipment during swing down, to ensure that exclusion zones are not encroached when performing floodlight maintenance. Mounting of lights on other substation structures such as landing structures, lightning masts, etc. is generally not acceptable, due to inaccessibility without a circuit outage and/or need for a ladder or EWP to carry out maintenance.

16.4 Panel Indication Sheets and Relay Reading Sheets

The Designer must produce for each protection panel, a Panel Indication Sheet and Series of associated Relay Reading Sheets. These sheets must be produced prior to the commissioning of the panel.

The Panel Indication Sheet consists of a full panel layout & identifies all hardware indications, flags, LED’s, etc. on the panel.

The Relay Reading Sheets are required for all relays equipped with LCD data screens, and consist of one sheet per relay on the panel. This sheet lists the required operational fault data indications, together with the key press sequences required to retrieve the data.

Indications and flags for non-software based relays (dumb) are also listed on the Panel Indication Sheet.

16.5 Nameplates, Signage, Labelling

16.5.1 General

Rating plates, nameplates, signs and labels must be located such that they can be easily and safely read from normal operating positions and access ways around the equipment, at ground or floor level.

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Full details of all signs, labels, etc. required, including content, sizes and details of lettering, in accordance with the respective template drawings must be provided in the project design, for ordering purposes.

Rating plates, nameplates, signs and labels installed on outdoor equipment must be of stainless steel or non-ferrous metal, with etched or engraved lettering and fixed with stainless steel screws or monel rivets. Indoor labels must be engraved traffolyte or other approved material.

16.5.2 Rating Plates, Nameplates and Operational Signs

Switchyard Operational Number signs are required on each HV operational point only. i.e. circuit breakers, disconnectors, earthing switches, voltage transformers, power transformers (all ratings), HV fuses, disconnectors and earth switches in RMU's and HV switchboards. Current transformers and surge diverters are not operating points and therefore must not be allocated operating numbers, although they may be shown on the Single Line Diagram Operating for information.

All switchyard operational signs must align with the approved Single Line Diagram Operating and all labels and signs must be clearly specified on appropriate drawings. For typical operational sign content, sizing, and layout refer to drawings 963817-01 to -07.

All CT and VT marshalling boxes must incorporate rating plates showing all relevant rating data of the associated HV plant. A second set of rating plates is usually sourced from the CT or VT manufacturer for installation on the appropriate marshalling box.

16.5.3 Labels

All equipment, operating devices, relays, etc. must be suitably labelled such that they can be readily identified from drawings. Circuit breaker and transformer control cubicles, control panels and relay panels must also be labelled. Cubicles and switchboard panels with rear access must also be labelled on the rear of the panel.

On manufactured equipment, most labels should be supplied and installed by the Equipment Manufacturer, however, it is the responsibility of the Substation Project Designer to check and provide any additional labelling needed to match the requirements of the project drawings. e.g. bay numbering, device identification, etc.

All labels, and in particular those supplied on equipment of overseas origin, must be submitted for approval prior to shipment of the equipment. All labels must be in the English language.

16.5.4 Safety Signs

Warning and safety signs must be installed around and within the substation to warn personnel of dangerous voltage levels, correct operating procedures and safety requirements within a substation. Warning signs must conform to the relevant Australian Standard and Work Health & Safety Act 2011. Refer also to ES000901R148 Workplace Signage Reference. The design, manufacture, and placement of the signs required for HV substations are specified in the Ergon Energy STNW3037 Standard for Substation Signage.

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ANNEX A – CAD HINTS AND TIPS

A.1 Grid and Unit Spacing

The standard workspace has a 10mm grid reference, a 4mm grid master and a 1mm grid unit spacing. All electrical drawings must be drawn using the 1mm unit. To ensure this is adhered to a unit lock is set. All lines and elements should be spaced at least 4mm apart.

A.2 CAD Standard Tools

The standard includes tools that are accessible from the Microstation task dialog box which consist of tool palettes that are docked on the left hand side of the Microstation application window. There is also an 'Ergon' menu at the top of the Microstation application window. Use these tools as they make the drafting process more efficient. They automatically set the level, colour and weights of the elements to conform to the standard.

A.3 Landscape Borders

The Ergon Energy borders include landscape and portrait variations but portrait borders make batch plotting more difficult and cumbersome. Always use the landscape borders and use the view rotate tool provided in the Ergon Energy Microstation task dialog box if the drawing is to be designed vertically such as for a panel cable connection diagram. The exit macro routine will automatically change the view back to the original on closing the drawing.

A.4 Working with Drawings Created Using Different Standards

Existing drawings that were revised or created using older standards need to be brought up to current CAD standards. The best way to achieve this is:

1. Create a new blank drawing from the standard seed file with a different file name and add the same size border using the Ergon menu.
2. Copy the elements from the existing drawing to the new file.
3. Use the power selector tool to update the elements to current standard. For example, all lines can be selected and moved to the lines level. Level display can be used to turn off all other levels, yellow lines selected and changed to weight of 3. All text and text nodes (multi-line text) can be selected and the change text attributes tool can be used to change the standard font.
4. Once complete the drawing can be closed but not added to the EDMS.
5. Save the dgn file in the EDMS checkout folder and give it the filename of the original file. The existing drawing's filename will need to be changed first to avoid a conflict. An underscore character positioned at the start of the filename is best used for this.
6. Open the new dgn with the correct filename and the EDMS will recognise this file as the linked original and automatically populate the border database fields.
7. The drawing can now be closed and checked back in to the EDMS.

A.5 Terminals and Connection Points

A cell has been created for terminals for schematic diagrams. This is a 2mm diameter white circle, with a line weight of 2. Do not use the old terminal cell that was a circle with horizontal lines. A connection point cell is a filled 1.5mm diameter white circle, with a line weight of 2. Both of these cells are available from the Ergon Energy Microstation task dialog box.

A.6 Text Justification

The standard text tools have a left-centre text justification. This is not always correct for all text placements. Do not use left-centre and move the text into a position that looks acceptable. When

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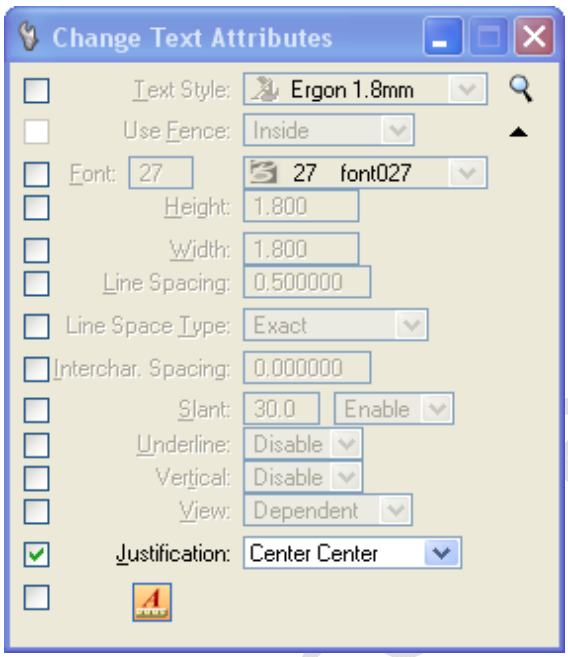
you place text look at the text and justify appropriate for the situation such as away from terminal points etc. Use centre-centre justification when you place text in a relay box etc. Some thought here makes future modifications and additions much simpler. The change text attributes tool can be used to change the justification of a number of selected text items in one operation.



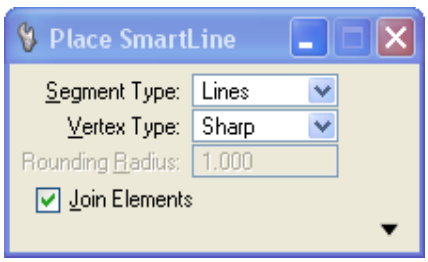
A.7 Revision Notes

These are notes placed within the frame of the border. They should state the project number, project description and details of changes to the drawing such as – “Added RTU 2 to Optonet loop”. Do not cloud revision notes or detail CAD modifications such as addition of new borders etc.

Example:

A.8 Using Microstation Tools

When drawing lines the join elements box must be selected as segmented lines are difficult to work with for future designs..



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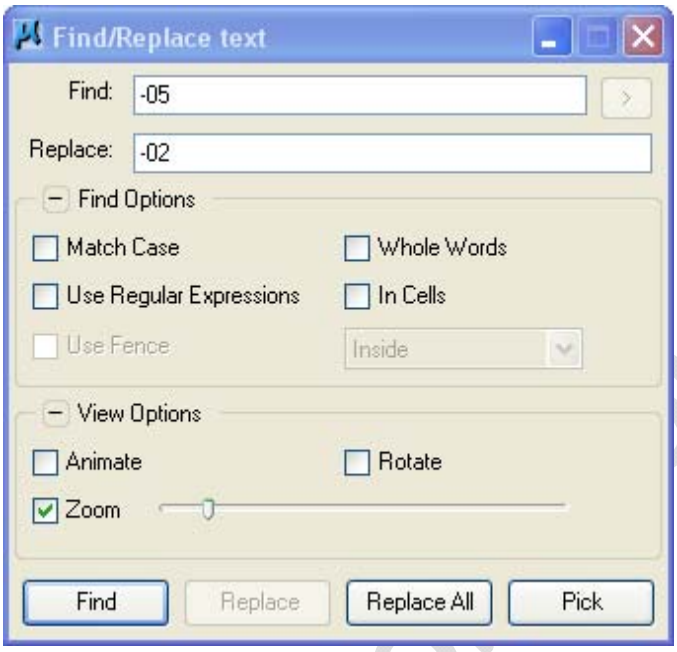
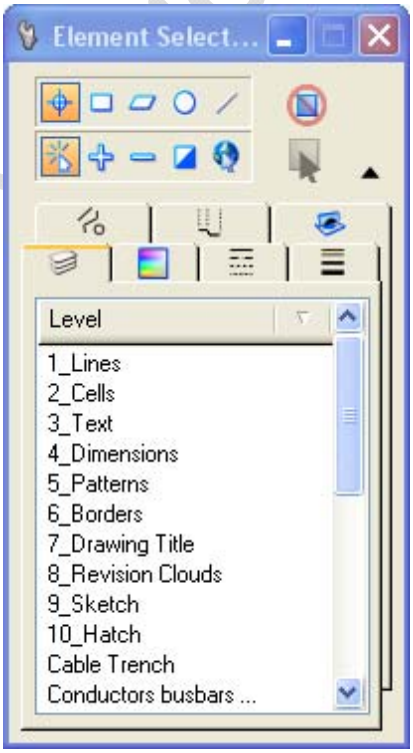
The find replace text tool can be used to fix multiple text changes on a drawing at once. For example if the cable connection diagram for =FA05 has been done and the appended wire number used a -05 then the drawing can be copied to use for =FA02 and wire numbers changed to -02 with the find replace text tool.



Use the extended element selection tools to select items of similar types or styles for modifications or updating to current standards.



Use the array tool to create multiple sets of items such as terminal blocks.

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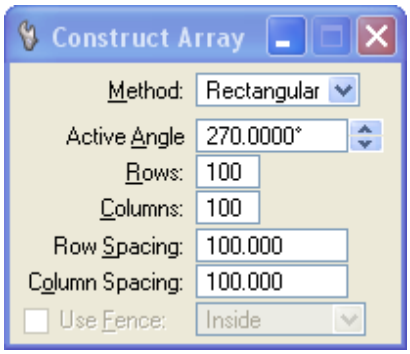
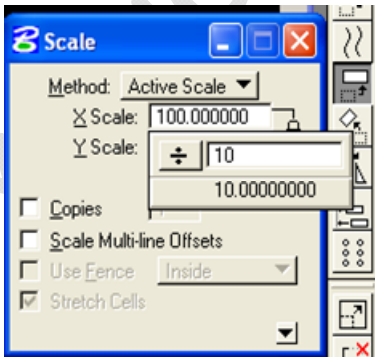


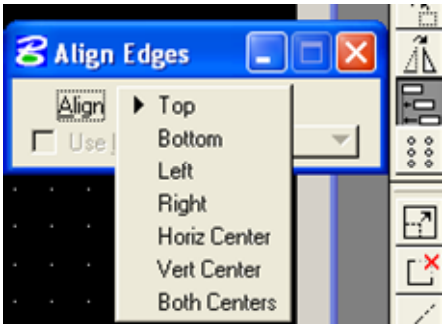
To add an additional dimension or remove one that is not required the ‘add’ or ‘remove’ vertex tool can be used.

When using line styles within an SLD some have arrow heads that point to the required logical operation. For example, if an initiate line is drawn and the arrow head is pointing in the wrong direction the arrow head can be reversed by using the TOOLS - CURVES – MODIFY CURVES – CHANGE CURVE DIRECTION tool.

If an element is required to be scaled, and the scalar value requires calculating, insert the division or multiplication calculation directly into the scale tool to get and set the value all at once.



Align elements with the multi-align tool “Align elements by edge”.



Microstation contains a tool called the FENCE. This tool can be used as a special selection tool, for copying sections of a drawing or can be used to manipulate elements. The most beneficial option is the fence stretch. First a section of the drawing is selected in a box or shape and then the manipulate fence content – stretch tool is used to pull an entire area of elements in a particular direction. This is used consistently to adjust the spacing between the elements of a drawing.

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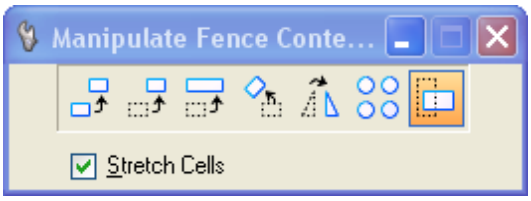
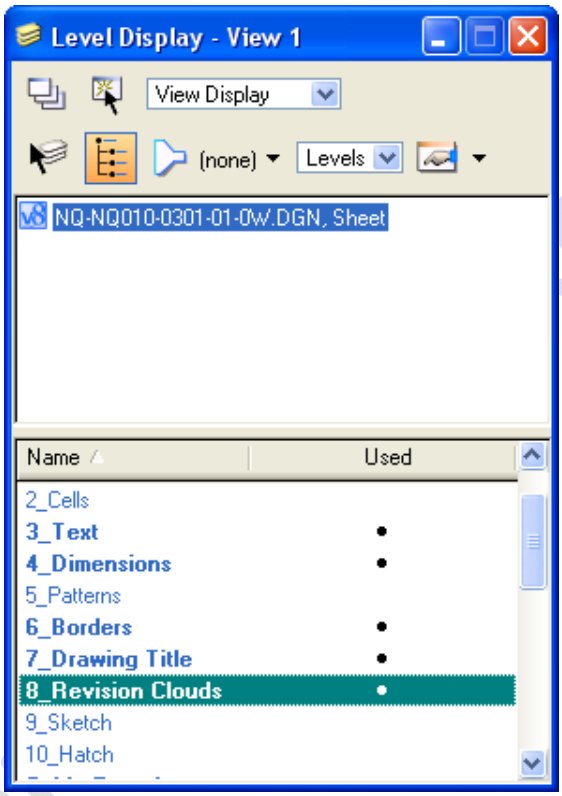


To delete all clouds, make the '8_Revision Clouds' level the active level by using the level display tool. Then turn all other levels off. Select all the clouds and remove them. Note that it is best to group revision code triangles and clouds together by selecting and pressing the control key while holding the 'g' key. This makes removal at as-built stage simple.



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ANNEX B – PERIOD CONTRACT PLANT

Ergon Energy has established period contracts with various manufacturers and suppliers as listed below:

Period Contract	Supply and Delivery Item	Supplier
2005/0783/T (expired)	Audio Frequency Load Control	Landis & Gyr
2010/0397/T	11/22kV Capacitor Bank	ABB
2008/6141/T	Item 1 – 36kV Outdoor Circuit Breakers – Dead Tank Item 2 – 72.5kV Outdoor Circuit Breakers – Dead Tank	Schneider Alstom
2009/0092/T	Item 1 – 36kV Outdoor Circuit Breakers – Live Tank Item 2 – 72.5kV Outdoor Circuit Breakers – Live Tank Item 3 – 145kV Outdoor Circuit Breakers – Live Tank Item 4 – 245kV Outdoor Circuit Breakers – Live Tank	ABB Alstom Alstom ABB
2011/0532/T	Cubicles and Plates	Preformed Line Products
2010/0310/T	Items 1B, 1C, 9B, 9C, 36B – 36kV Outdoor Current Transformer 1A Secondary Items 3C, 6B, 6C, 10B, 10C, 14B, 14C, 18B, 18C, 19B, 19C, 20B, 20C, 22C, 31B, 31C, 32B, 32C, 33B, 33C – 72.5kV Outdoor Current Transformer 1A Secondary Items 5B, 5C, 8B, 8C, 11C, 17B, 17C, 21C, 30B, 30C – 145kV Outdoor Current Transformer 1A Secondary Items 35B, 35V, 37B, 37C – 245kV Outdoor Current Transformer 1A Secondary	Koncar Koncar Koncar Koncar
2004/0346/T (expired)	Item 12 – 36kV Outdoor Current Transformer 5A Secondary Items 4, 7, 13 – 72.5kV Outdoor Current Transformer 5A Secondary	Koncar Koncar
2005/0659/T	Item 1 – 125V VRLA Dual String Battery Item 2 – 110V VRLA Dual String Battery Item 3 – 48V VRLA Dual String Battery Item 4 – 32V VRLA Dual String Battery Item 11 – 125V Battery Charger Item 12 – 110V Battery Charger Item 13 – 48V Battery Charger Item 14 – 32V Battery Charger Items 41-49 – DC Distribution Boards Items 51-55 – Battery Isolation Panels	Century Yuasa Century Yuasa Century Yuasa Century Yuasa Exide Technologies Exide Technologies Exide Technologies Exide Technologies Battery Energy Century Yuasa
2011/0223/T	12V Dual String Recloser Battery	Century Yuasa
2010/0132/T	Part A - 36kV Outdoor Disconnectors and Earth Switches	AK Power Solutions

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Period Contract	Supply and Delivery Item	Supplier
	Part B – 72.5kV Outdoor Disconnectors and Earth Switches	AK Power Solutions
	Part C – 145kV Outdoor Disconnectors and Earth Switches (Manual and Motorised)	AK Power Solutions
	Part D – 245kV Outdoor Disconnectors and Earth Switches (Motorised)	AK Power Solutions
	Part E – 72.5kV Stand Alone Earth Switches	AK Power Solutions
	Part F – 145kV Stand Alone Earth Switches	AK Power Solutions
2006/0132/T	Items 1, 2 – 132/66/11kV Power Transformers	Wilson Transformer Company
	Item 3 – 132/66/11kV Power Transformers	ABB
	Item 4 – 132/33/11kV Power Transformers	Wilson Transformer Company
	Items 5, 6 – 132/33/11kV Power Transformers	ABB
	Item 7 – 132/22kV Power Transformers	Wilson Transformer Company
	Items 8, 9, 10 – 132/22kV Power Transformers	ABB
	Items 11, 12 – 132/211kV Power Transformers	ABB
	Item 13 – 110/66/11kV Power Transformers	Wilson Transformer Company
	Items 14. 15 – 110/66/11kV Power Transformers	ABB
	Item 16 – 110/33/11kV Power Transformers	Wilson Transformer Company
	Items 17. 18 – 110/33/11kV Power Transformers	ABB
	Items 19, 20 – 110/11kV Power Transformers	ABB
	Items 21, 22, 23, 24, 25 – 66/33/11kV Power Transformers	ABB
	Items 26, 27, 28, 29 – 66/22kV Power Transformers	Wilson Transformer Company
	Items 30, 31, 32, 33 – 66/11kV Power Transformers	Wilson Transformer Company
	Items 34 – 33/22kV Power Transformers	Wilson Transformer Company
	Items 35, 36, 37, 38 – 33/11kV Power Transformers	Wilson Transformer Company
2012/0252/T	Power Quality Monitors	CSE Uniserve
2010/048/T	Item 1 – 12kV Indoor Metal Enclosed Withdrawable Switchboard	iPower Solutions
	Item 2, 3 – 24kV Indoor Metal Enclosed Withdrawable Switchboard	iPower Solutions
	Item 4 – 36kV Indoor Metal Enclosed Withdrawable Switchboard	iPower Solutions
2006/084/T	Item 1 – 24kV Outdoor Inductive Voltage Transformer	Adapt Australia
	Item 2 – 36kV Outdoor Inductive Voltage Transformer	Adapt Australia
	Item 3 – 72.5kV Outdoor Inductive Voltage Transformer	Adapt Australia
	Item 4 – 72.5kV Outdoor Capacitive Voltage Transformer	Adapt Australia
	Item 5 – 123kV Outdoor Capacitive Voltage Transformer	Adapt Australia
	Item 6 – 145kV Outdoor Capacitive Voltage Transformer	Adapt Australia

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Period Contract	Supply and Delivery Item	Supplier
2009/0369/T	Protection Relays	Refer ANNEX C – PERIOD CONTRACT PROTECTION RELAYS

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ANNEX C – PERIOD CONTRACT PROTECTION RELAYS

Refer to Ergon Energy Substation Materials Catalogue for a detailed list of Manufacturer Part numbers and Ergon Energy Stock codes.

Protection Function	Supplier	Manufacturer Model
Feeder Management	Schweitzer Engineering Laboratories Pty Ltd	03516
	AREVA T&D Australia Limited	P142
Sensitive / Neutral Earth Fault	AREVA T&D Australia Limited	P120
Capacitor Bank	ABB	SPAJ 160 C
High Impedance Differential	Relay Monitoring Systems	1M123 (incl. 2V73, 2V75, & 2HSM519)
	AREVA T&D Australia Limited	MFAC34
Biased Differential (2 winding)	Schweitzer Engineering Laboratories Pty Ltd	0387A
	AREVA T&D Australia Limited	P642
Biased Differential (3 winding)	Schweitzer Engineering Laboratories Pty Ltd	03876
	AREVA T&D Australia Limited	P643
Line Differential (2 Terminal)	Schweitzer Engineering Laboratories Pty Ltd	0311L (with 3094 media converter as required)
	AREVA T&D Australia Limited	P543 (with P591 media converter as required)
Line Differential (3 Terminal)	Schweitzer Engineering Laboratories Pty Ltd	0311L (with 3094 media converter as required)
	AREVA T&D Australia Limited	P543 (with P591 media converter as required)
Distance	Schweitzer Engineering Laboratories Pty Ltd	0311C
	AREVA T&D Australia Limited	P445
Underfrequency	Relay Monitoring Systems	2H34
Multi-trip (latching)	Relay Monitoring Systems	2HSM519

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Protection Function	Supplier	Manufacturer Model
	AREVA T&D Australia Limited	MVAJ205
Multi-trip (non-latching) Note: not available as period contract items)	Relay Monitoring Systems	2HSM512
	AREVA T&D Australia Limited	MVAJ101

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ANNEX D – RELAY SELECTION

Overview

This document provides a guide for selection of protection relays for typical applications. This guideline is not intended to supersede specific recommendations contained in Project Scope Statements. Where a Project Scope Statement is provided and contradicts information in this guide the Project Scope Statement is to be used.

All relays used on Ergon Energy's network must be from the Ergon Energy period contract. All relays must be wired according to the protection application guides published in EDMS. Where a protection application guide is not available or not suitable the Operational Technology Team must be contacted at the design stage.

Bus Protection

Ergon Energy has two manufacturers of high impedance bus protection relay on Period Contract, the MFAC34 and RMS 1M123. For retrofit applications either relay may be used. The Protection Team should be contacted prior to order to confirm the correct setting range required. Typically the RMS 1M123 must be used as the main protection. The MFAC34 must be used as the backup protection.

For distribution busbars the SEL351-6 relays must be used for Summated Overcurrent protection (backup protection). This relay has been selected to provide a diversity of manufacturer when providing backup for the distribution feeders.

Circuit Breaker Failure Protection

For protection schemes that require duplicated Circuit Breaker Failure (CBF) protection (blind spot protection) the main protection must be the SEL351-6 relay. The backup protection must be the Schneider MiCOM P142.

Where duplicated CBF protection is not required either the MiCOM P142 or SEL351-6 relay may be used. Ideally designs will allow for a 4U, 19 inch relay to ensure compatibility for future augmentation.

Transformer Protection

- Auto Transformers

Must have a main protection biased differential protection comprising of an SEL387A. The backup must be a MFAC34 high impedance differential protection. The high impedance differential protection scheme must have a MiCOM P142 relay installed for each winding to provide CB failure protection and backup Overcurrent.

- Galvanically Isolated Transformers

Where the transformer is large enough to warrant duplicated protection (X and Y or Main and Backup) it must be duplicated differential protection. A differential protection relay typically requires the same number of current transformers and takes up less panel space than a corresponding high voltage and low voltage Overcurrent scheme. The cost of a single differential relay is approximately the same as two Overcurrent relays.

The main protection must be an SEL387A. The backup protection must be a MiCOM P642.

In applications where an SEL387 relay needs to be used with a mix of 1 and 5A CT secondaries (e.g. 1A HV and 5A LV) a 1A SEL relay must be used and interposing CT's installed on the 5A secondaries.

When retro fitting transformer differential protection relays that were externally compensated (e.g. delta connected line CT's). The CT circuits must be reconfigured to Star and compensation undertaken in the differential relay.

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Distribution Feeder Protection

The MiCOM P142 relay should be selected for typical distribution feeder protection applications. For applications where duplicated feeder Overcurrent protection is required the Main Protection must be the SEL351-6 and the Backup must be the MiCOM P142.

Ideally designs for feeder protection relays should allow for a relay with a full 19 inch rack, 4u high cut out so that future retrofitting of any period contract relay can be undertaken.

Capacitor Bank Protection

Capacitor bank protection must be designed using the SEL351-6 and the SPAJ160C protection relays. This arrangement aligns with the protection supplied by the modular capacitor banks supplied by ABB. The SEL solution is also scalable and allows use on 2 stage capacitor banks.

For capacitor banks that have a unbalance VT fitted, the unbalance VT must be wired into the VS input of the SEL351-6.

Subtransmission Feeder

- Duplicated Distance

Where the feeder is a radial sub-transmission feeder and has been deemed suitable for distance protection it should be configured for non-communicating distance protection. The main protection must be the SEL311C relay; the backup must be the MiCOM P445.

Where the feeder is part of an interconnected network the distance protection relays must be configured for communicating distance. The MiCOM P445 Protection Application Guide for communicating distance includes an SEL 250x IO module. With this arrangement all communicating distance protection are made to be Mirrorbit™ compatible. With this arrangement it is possible to have a MiCOM relay working in conjunction with an SEL relay at the remote line end. With this philosophy there is no requirement to have the relay manufacturer align at both ends of the feeder and the same convention of MiCOM as backup, SEL as main can be maintained for the communicating scheme in all scenarios.

- Duplicated Differential

For new feeders or in circumstances where the remote relays need to be modified the main protection must be the SEL311L relay. The backup protection must be the MiCOM P543. In instances where the remote end relay already exists it is preferable to ensure that the relay being installed is part of the same protection scheme. That is the main protection relays should be a matching set as well as the backup relays.

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ANNEX E – PROTECTION APPLICATION GUIDES

Drawing	Description
EESS-11120-01	ELSPEC G4420 POWER QUALITY ANALYSER LAYOUT & SCHEMATIC
EESS-11121-01	INTEGRA 1530 METER LAYOUT & SCHEMATIC
EESS-11122-02	ALSTOM M571 CVT MONITOR ADDRESSING & ALLOCATION INFORMATION
EESS-11122-01	ALSTOM M571 CVT MONITOR LAYOUT & SCHEMATIC
EESS-11170-01	SEL-351-6 DISTRIBUTION FEEDER - TYPE 2 LAYOUT & SCHEMATIC
EESS-11170-02	SEL-351-6 DISTRIBUTION FEEDER - TYPE 2 ADDRESSING & ALLOCATION INFORMATION
EESS-11171-01	MiCOM P142 DISTRIBUTION FEEDER OVERCURRENT LAYOUT & SCHEMATIC
EESS-11171-02	MiCOM P142 DISTRIBUTION FEEDER OVERCURRENT ADDRESSING & ALLOCATION INFORMATION
EESS-11172-01	SEL-351-6 & SPAJ 160C CAPACITOR BANK PROTECTION LAYOUT & SCHEMATIC
EESS-11172-02	SEL-351-6 & SPAJ 160C CAPACITOR BANK PROTECTION ADDRESSING & ALLOCATION INFORMATION
EESS-11173-01	MiCOM P142 & SPAJ 160C CAPACITOR BANK PROTECTION LAYOUT & SCHEMATIC
EESS-11173-02	MiCOM P142 & SPAJ 160C CAPACITOR BANK PROTECTION ADDRESSING & ALLOCATION INFORMATION
EESS-11174-01	SEL-351-6 CB FAIL LAYOUT & SCHEMATIC
EESS-11174-02	SEL-351-6 CB FAIL ADDRESSING & ALLOCATION INFORMATION
EESS-11175-01	MiCOM P142 CB FAIL APPLICATION GUIDE LAYOUT & SCHMATIC
EESS-11175-02	MiCOM P142 CB FAIL APPLICATION GUIDE ADDRESSING & ALLOCATION INFORMATION
EESS-11176-01	SEL-351-6 SUMMATED BUS OVERCURRENT LAYOUT & SCHEMATIC
EESS-11176-02	SEL-351-6 SUMMATED BUS OVERCURRENT ADDRESSING & ALLOCATION INFORMATION
EESS-11177-01	MiCOM P142 SUMM BUS OVERCURRENT LAYOUT & SCHEMATIC
EESS-11177-02	MiCOM P142 SUMM BUS OVERCURRENT ADDRESSING & ALLOCATION INFORMATION
EESS-11178-01	SEL-351-6 TRANSF HV OVERCURRENT LAYOUT & SCHEMATIC
EESS-11178-02	SEL-351-6 TRANSF HV OVERCURRENT ADDRESSING & ALLOCATION INFORMATION
EESS-11179-01	MiCOM P142 TRANSF HV OVERCURRENT LAYOUT & SCHEMATIC
EESS-11179-02	MiCOM P142 TRANSF HV OVERCURRENT ADDRESSING & ALLOCATION INFORMATION
EESS-11180-01	SEL-351-6 TRANSF LV OVERCURRENT LAYOUT & SCHEMATIC
EESS-11180-02	SEL-351-6 TRANSF LV OVERCURRENT ADDRESSING & ALLOCATION INFORMATION

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Drawing	Description
EESS-11181-01	MiCOM P142 TRANSF LV OVERCURRENT LAYOUT & SCHEMATIC
EESS-11181-02	MiCOM P142 TRANSF LV OVERCURRENT ADDRESSING & ALLOCATION INFORMATION
EESS-11182-01	SEL-387A (ADD I/O) TRANSFORMER DIFFERENTIAL LAYOUT & SCHEMATIC
EESS-11182-02	SEL-387A (ADD I/O) TRANSFORMER DIFFERENTIAL ADDRESSING & ALLOCATION INFORMATION
EESS-11183-01	MiCOM P642 TRANSFORMER DIFFERENTIAL LAYOUT & SCHEMATIC
EESS-11183-02	MiCOM P642 TRANSFORMER DIFFERENTIAL ADDRESSING & ALLOCATION INFORMATION
EESS-11185-01	SEL-387-6 CURRENT DIFFERENTIAL OVERCURRENT APPLICATION INDEX
EESS-11185-04	SEL-387-6 AUTO TRANSFORMER WITH LOADED TERTIARY LAYOUT & SCHEMATIC
EESS-11185-05	SEL-387-6 AUTO TRANSFORMER WITH LOADED TERTIARY ADDRESSING & ALLOCATION INFORMATION
EESS-11185-06	SEL-387-6 HV BREAKER AND A HALF WITH HV REF LAYOUT & SCHEMATIC
EESS-11185-07	SEL-387-6 HV BREAKER AND A HALF WITH HV REF ADDRESSING & ALLOCATION INFORMATION
EESS-11185-08	SEL-387-6 HV BREAKER AND A HALF WITH LV REF LAYOUT & SCHEMATIC
EESS-11185-09	SEL-387-6 HV BREAKER AND A HALF WITH LV REF ADDRESSING & ALLOCATION INFORMATION
EESS-11185-10	SEL-387-6 LV BREAKER AND A HALF WITH HV REF LAYOUT & SCHEMATIC
EESS-11185-11	SEL-387-6 LV BREAKER AND A HALF WITH HV REF ADDRESSING & ALLOCATION INFORMATION
EESS-11185-12	SEL-387-6 LV BREAKER AND A HALF WITH LV REF LAYOUT & SCHEMATIC
EESS-11185-13	SEL-387-6 LV BREAKER AND A HALF WITH LV REF ADDRESSING & ALLOCATION INFORMATON
EESS-11187-01	SEL-311L (ADD I/O) FEEDER DIFFERENTIAL LAYOUT & SCHEMATIC
EESS-11187-02	SEL-311L (ADD I/O) FEEDER DIFFERENTIAL ADDRESSING & ALLOCATION INFORMATION
EESS-11188-01	MiCOM P543-0K FEEDER DIFFERENTIAL LAYOUT & SCHEMATIC
EESS-11188-02	MiCOM P543-0K FEEDER DIFFERENTIAL ADDRESSING & ALLOCATION INFORMATION
EESS-11189-01	SEL-311C (ADD I/O) FEEDER DISTANCE LAYOUT & SCHEMATIC
EESS-11189-02	SEL-311C (ADD I/O) FEEDER DISTANCE ADDRESSING & ALLOCATION INFORMATION
EESS-11190-01	MiCOM P445 FEEDER DISTANCE LAYOUT & SCHEMATIC
EESS-11190-02	MiCOM P445 FEEDER DISTANCE ADDRESSING & ALLOCATION INFORMATION
EESS-11191-01	RMS 1M123 HIGH IMPEDANCE BUS PROTECTION LAYOUT & SCHEMATIC
EESS-11192-01	SCHNEIDER MFAC34 HIGH IMPEDANCE BUS PROTECTION LAYOUT & SCHEMATIC
EESS-11193-01	MiCOM P120 NEUTRAL EARTH FAULT LAYOUT & SCHEMATIC

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Drawing	Description
EESS-11193-02	MiCOM P120 NEUTRAL EARTH FAULT ADDRESSING & ALLOCATION INFORMATION
EESS-11194-01	SEL 351-6 & SPAJ 160 C FOR 2 STAGE CAPACITOR BANK LAYOUT & SCHEMATIC
EESS-11195-02	NULEC RECLOSER WITH CAPM CONTROLLER ADDRESSING & ALLOCATION INFORMATION
EESS-11196-01	MiCOM P643 SUMMATED BUS OVERCURRENT LAYOUT & SCHEMATIC
EESS-11196-02	MiCOM P643 SUMMATED BUS OVERCURRENT ADDRESSING & ALLOCATION INFORMATION
EESS-11198-02	SCHNEIDER RL SERIES SECTIONALISER/LBS WITH ADVC2 CONTROLLER ADDRESSING & ALLOCATION INFORMATION
EESS-11199-02	SCHNEIDER RECLOSER WITH ADVC2 CONTROLLER ADDRESSING & ALLOCATION INFORMATION
EESS-11202-01	MiCOM P120 NEUTRAL CHECK LAYOUT & SCHEMATIC
EESS-11202-02	MiCOM P120 NEUTRAL CHECK ADDRESSING & ALLOCATION INFORMATION
EESS-11203-01	SEL-311C (ADD I/O) COMMUNICATING FEEDER DISTANCE LAYOUT & SCHEMATIC
EESS-11203-02	SEL-311C (ADD I/O) COMMUNICATING FEEDER DISTANCE ADDRESSING & ALLOCATION INFORMATION
EESS-11204-01	MiCOM P445 & SEL 2505/2506 COMMUNICATING FEEDER DISTANCE LAYOUT & SCHEMATIC
EESS-11204-02	MiCOM P445 & SEL 2505/2506 COMMUNICATING FEEDER DISTANCE ADDRESSING & ALLOCATION INFORMATION

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ANNEX F – CDEGS SOFTWARE PARAMETER TABLES

The following parameter table lists the common parameters a designer may need to modify when designing an earthing grid using the SES Software CDEGS.

Input Module: RESAP

Parameter	Software Default	Required Value	Comments
Specify			
Module Description	<blank>	Enter description of model	
Run Identification	<Use Job-ID>	<Use Job-ID>	
System of Units	<Metric>	<Metric>	
Measurements			
Method	<Wenner>	<Wenner>	
Type	<Resistance (Ohms) R=V/I>	<Resistance (Ohms) R=V/I>	
Options	<Account for Probe Depth>	<Ignore Probe Depth>	
Plot Axis Type	<Logarithmic X / Logarithmic Y>	<Logarithmic X / Logarithmic Y>	
Plot Data Type	<Resistivity>	<Resistivity>	
Soil Type			
Soil Type	<Horizontal Layers>	<Horizontal Layers>	Select <Uniform> if soil resistivity test results have not been verified by testing
Number of Soil Layers	<Determine Automatically>	<Determine Automatically>	
Computations – use default parameters			
Optimisation – use default parameters			

Examine Module: RESAP

Parameter	Software Default	Required Value	Comments
Plot Title	<blank>	Enter description of plot	
Units	<Metric>	<Metric>	
Types of Scale	<Logarithmic X / Logarithmic Y>	<Logarithmic X / Logarithmic Y>	
Plotting Options	Plot Soil Model Include Soil Model Table	Plot Soil Model Include Soil Model Table	

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Input Module: MALZ

Parameter	Software Default	Required Value	Comments
Specify			
Module Description	<blank>	Enter description of model	
Run Identification	<Use Job-ID>	<Use Job-ID>	
System of Units	<Metric>	<Metric>	
Printout	<Detailed>	<Detailed>	
Allow Large Radius (>1.0 m)	<unchecked>	<unchecked>	
System – Lead Types (Bus to Conductor Impedances)			
Type No -1	<unconnected>	<unconnected>	Use Lead Type = -1 for all grid conductors except the conductor which the fault energisation is applied
Type No 0 (def)	<connected>	<connected>	Use Lead Type = 0 for the conductor which the fault energisation is applied. Default impedances for R & X of 0 ohms
System – Conductor Types (Ground Conductors)			
Type No -1 - Plastic	Not used		
Type No 0 - Default	Use Conductor Type = 0 with default parameters for all earth grid conductors		
System – Conductor Coating Types			
Type No -1 Insulated	Not used		
Type No 0 (def) Default Coating	Use Coating Type = 0 with default parameters for all earth grid conductors		
System – Energisation Source			
Input Method	<Cartesian> or <Polar>	<Cartesian>	
Bus 1 <Identification>	<blank>	Enter description of energisation bus	Eg, “Source”
Bus 1 <Energisation Type>	<Current>	<Current>	
Bus 1 <Real Part>	<blank>	Enter fault current in Amps	
Bus 1 <Imaginary Part>	<blank>	0	
Reference Bus	<Bus #1_source>	<Bus #1_source>	

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Parameter	Software Default	Required Value	Comments
System – Main Ground Conductors			
Conductor Positions	<blank> Xs (origin), Xp (end), Ys (origin), Yp (end)	Conductor grid positions (in meters) as defined in SESCAD	
Conductor Positions	<blank> Zs (origin), Zp (end)	Conductor burial depth, typically use 0.5m	A positive "Z" value indicates below ground
Conductor Radius (metres)	<blank>	0.00525 (70mm^2 CSA) 0.00690 (120mm^2 CSA) 0.00750 (150mm^2 CSA) 0.00875 (185mm^2 CSA) 0.00965 (240mm^2 CSA) 0.01050 (300mm^2 CSA)	Based on nominal diameter for stranded Cu conductors
System – Advanced – use default parameters			

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ANNEX G – NOISE CADNA SOFTWARE PARAMETER TABLE

The following parameter table lists the common parameters a designer may need to modify when developing a substation noise model using the CadnaA Software.

Parameter	Software Default	Required Value	Comments
Calculation Configuration			
Standards/Guidelines	ISO 9613	ISO 9613	
Ground Attenuation	Not spectral	Spectral, all sources	
Temperature (degree)	10	20	
Rel. Humidity (%)	70	70	
Meteorology	none	Cmet, C0 from wind statistics	
Note: Ergon Energy recommends using software (CadnaA) default values for all other calculation configuration parameters.			
Grid Properties			
Receiver Spacing (dx, dy)	10m	0.1m	
Receiver Height	4m	1.5m	

Other Ergon Energy recommended modelling methods/settings:

1. Noise point source must be used to represent any noise source, noise sources' physical shape or sizes are not considered. Noise point source must be inserted at where the physical centre of the noise source is. The height of the point source must be set at 2/3 of the total height of noise source as per AS2374.6

2. When enter noise source data, the "spectrum" must be changed to "A-weighted" unless otherwise specified by manufacturer.

3. The reflection loss coefficient of building material must be selected for building bricks, sound absorbing wall, and fence according to their materials.

For Crushed Rock ground absorption coefficient must be set to 0.1

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ANNEX H – CYMCAP SOFTWARE PARAMETER TABLE

The following parameter table lists the common parameters a designer may need to modify when modelling a cable installation using the CymCap Software.

Parameter	Software Default	Required Value	Comments
Set Up New Study			
Study Identification ID	<blank>	Enter ID of study	
Study Identification Title	<blank>	Enter Title of study	
Execution Description Title	<blank>	Enter Title of execution	
Execution Description Comments	<blank>	Enter comments of execution	
Solution Option			
Steady-state Analysis	**<Equally loaded>**	**<Equally loaded>** **<Unequally loaded>** **<Temperature>**	**Use "Equally loaded" option when same cable type is selected and cable current is identical, for example, multiple cables per phase installation for a transformer cable.** **Use "Unequally loaded" option when cable current is not identical or dissimilar cables are selected. For example, feeder exit cables with various loads.** **Use Temperature when cable current is known and temperature is sought.**
Transient Analysis	Unselected	Unselected Selected	Select when transient analysis is required
Installation Type – multiple duct banks/backfills/castings			
Type of multiple installation	<Select multiple duct banks/backfills installation>	<Select multiple duct banks/backfills installation>	
Configuration	No input	Input number of ductbanks from ductbanks library input number of non-standard ductbanks Input number of backfills or soil layers	
General data – Ambient Soil Temperature (degrees)	**25.0**	**35.0**	**Ergon Energy Substation Standard requires power cables to be sized and selected to meet maximum ambient soil temperature of 35 degrees in Summer.**
General data – Native soil thermal	1.000	Native soil thermal resistivity from soil test results	Thermal conductivity of commonly used materials can be obtained from:

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Parameter	Software Default	Required Value	Comments
resistivity, C-M/W			http://www.engineeringtoolbox.com/thermal-conductivity-d_429.html For reference only!
Cable and circuit Installation setup	Non-selected	Select circuits and cable installation configuration	Cable installation configuration need to be compatible with cables type selected
Power factor	1.0	1.0	
Conductor Temperature (degrees)	90.0	90.0	Use cable manufacturer recommended value for short term over-loaded scenario
Load Factor	1.0	1.0	Use 1.0 for long term worst case scenario. Use other value if available
Sheaths/Shield Bonding	**Non**	**1 – CON, sheaths bonded ends, triangular configuration** **1- CON, Sheaths single point bonded triang. Configuration**	**For single-core cable at 33kV and below, single point bonded sheath can be used when required rating cannot be achieved with double ends bonding.** **For all other situations, use double ends bonding.**
Loss Factor Constant	0.30	0.30	
Duct construction	Non	PVC duct in concrete or buried	
Cables Touching	Single conductor cables NOT touching	Single conductor cables NOT touching	
Duct Dimensions	In = 0.00, Out = 0.00mm	Input inside and outside diameters of PVC duct	
Simulation preferences			
Units	Metric	Metric	
Frequency	60Hz	50Hz	
Cyclic Loading	Neher-McGrath	Neher-McGrath	
Electrical Interaction Between Circuits	Not Active	Not Active Active	
Global Short Circuit time	0.1s	0.1s	
Installation type – Cables in Backfill			
Backfill data			
Height, meter	0.00	Height of cable trench	
Width, meter	0.00	Width of cable trench	
X of horizontal centre of backfill,	0.00	X of horizontal centre of	

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Parameter	Software Default	Required Value	Comments
meter		backfill, meter	
Y of vertical centre of backfill, meter	0.00	Y of vertical centre of backfill, meter	
Backfill thermal resistivity, C-M/W	1.000	Backfill thermal resistivity tested from material samples provided by supplier	A low value backfill thermal resistivity can only be used in simulation when the material availability is confirmed and cost of construction has been approved
Installation type – Cables directly buried			
Consider non-isothermal earth surface (if selected for simulation)	0		
Consider effect of soil dryout around cables (if selected for simulation)	Dry soil thermal resistivity, C-M/W Critical soil temperature, degrees C	Soil thermal resistivity tested when dry	
Installation type – Cables in air			
Shaded cables	unselected	Unselected selected	Select this option when cable is in air and shaded
Intensity of solar radiation	**1000.00 W/M2**	**1100.00 W/M2**	**As per Ergon Standards SS-A-4.4 Ver 2A**
Surface absorption coefficient	0.00	Use drop down list to select commonly used materials Or manually input coefficient if known	
Installation type – Cables in tunnel installation			
Cable in tunnel data			
Height, meter	0.000	Height of tunnel	
Width, meter	0.000	Width of tunnel	
X of horizontal centre of tunnel, meter	0.000	X of horizontal centre of tunnel, meter	
Depth from the earth surface to…	The centre of tunnel, The top of the tunnel	Value from design Value from design	

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Installation type – Cables in troughs installation			
Troughs data			
Width, Height, Left, Depth, meter	0.000	Values from troughs construction design	
Inside texture and thermal resistivity, C-M/W	Sand (type 2) 1.000	Use drop down list	
Frame texture and thermal resistivity, C-M/W	Cement (type 1) 1.000	Use drop down list	

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ANNEX I – STANDARD DESIGN MODULES

Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
SUBSTATIONS				
Z6-32D Substation	Install a 66/11kV 32MVA substation, including foundations, steelwork, modular buildings, HV plant and equipment, and secondary systems	Z6-32D Single Line Diagrams Z6 Substation General Arrangement Use design modules for:- • Modular Switchgear Building • Modular Control Building • 66kV Transformer Bay • 66/11kV Transformer 32MVA • 66kV Feeder Bay • 66kV Bus Coupler Bay • 11kV Incomer Bay • 11kV Feeder Bay • 11kV Bus Coupler Bay • 11kV Capacitor Bank	Z6-32D Substation	S_Z632D_SUB
Z6-20D Substation	Install a 66/11kV 20MVA substation, including foundations, steelwork, Modular buildings, HV plant and equipment, and secondary systems	Z6-20D Single Line Diagrams Z6 Substation General Arrangement Use design modules for:- • Modular Switchgear Building • Modular Control Building • 66kV Transformer Bay • 66/11kV Transformer 20MVA • 66kV Feeder Bay • 66kV Bus Coupler Bay • 11kV Incomer Bay • 11kV Feeder Bay	Z6-20D Substation	S_Z620D_SUB

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
		• 11kV Bus Coupler Bay • 11kV Capacitor Bank		
SUBSTATION BAYS				
66kV Transformer Bay	Install a 66kV Transformer Bay, including foundations, steelwork, HV plant and equipment, and secondary systems • Excludes transformer	Z6-32D Single Line Diagrams (or Z6-20D) Z6 Substation General Arrangement Use design modules for:- • 66kV Outdoor Circuit Breaker • 66kV Current Transformer • 66kV Disconnector • 66kV Surge Arrester (transformer) • 66kV Transformer Protection Panel • 66kV RTU Panel (RTU 1 or RTU 2) • 11kV Metering Panel • 66kV Bus Protection Panel	66kV Transformer Bay	S_66TFR32_OD
66kV Feeder Bay	Install a 66kV Feeder Bay, including foundations, steelwork, HV plant and equipment, and secondary systems	Z6-32D Single Line Diagrams (or Z6-20D) Use design modules for:- • 66kV Outdoor Circuit Breaker • 66kV Current Transformer • 66kV Voltage Transformer • 66kV Disconnector • 66kV Surge Arrester (feeder) • 66kV Feeder Protection Panel – Current Diff or Distance • 66kV RTU Panel (RTU 1 or RTU 2) • 66kV Metering Panel • 66kV Bus Protection Panel	66kV Feeder Bay	S_66FDR_OD
66kV Bus Coupler Bay	Install a 66kV Bus Coupler Bay, including foundations,	Z6-32D Single Line Diagrams (or Z6-20D)	66kV Bus Coupler Bay	S_66BUS_OD

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
	steelwork, HV plant and equipment, and secondary systems	Use design modules for:- • 66kV Outdoor Circuit Breaker (if required) • 66kV Current Transformer (if required) • 66kV Disconnector • 66kV RTU Panel (RTU 1) • 66kV Bus Protection Panel		
11kV Incomer Bay	Install an 11kV Transformer Incomer Bay, including HV plant and equipment, and secondary systems • Based on I-Power 11kV Switchboard	Z2-32D Single Line Diagrams (or Z2-20D) Z6-32D Single Line Diagrams (or Z6-20D) Z7-32D Single Line Diagrams (or Z7-20D) T3-10 Single Line Diagrams 11kV Indoor Switchboard General Arrangement 11kV Indoor Switchboard Standard Earthing Use design modules for:- • 66/11kV Transformer Protection Panel • 11kV RTU Panel (RTU 3 or RTU5) • 11kV Bus Protection Panel	11kV Transformer Incomer Bay	
11kV Feeder Bay	Install an 11kV Feeder Bay, including HV plant and equipment, and secondary systems • Based on I-Power 11kV Switchboard	Z2-32D Single Line Diagrams (or Z2-20D) Z6-32D Single Line Diagrams (or Z6-20D) Z7-32D Single Line Diagrams (or Z7-20D) T3-10 Single Line Diagrams 11kV Indoor Switchboard General Arrangement 11kV Indoor Switchboard Standard Earthing Use design modules for:- • 11kV Feeder Protection Panel • 11kV RTU Panel (RTU 3, RTU4, or RTU5) • 11kV Bus Protection Panel	11kV Feeder Bay	

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
11kV Capacitor Bank Bay	Install an 11kV Capacitor Bank Bay, including HV plant and equipment, and secondary systems • Based on I-Power 11kV Switchboard	Z2-32D Single Line Diagrams (or Z2-20D) Z6-32D Single Line Diagrams (or Z6-20D) Z7-32D Single Line Diagrams (or Z7-20D) 11kV Indoor Switchboard General Arrangement 11kV Indoor Switchboard Standard Earthing Use design modules for:- • 11kV Capacitor Bank • 11kV Capacitor Bank Protection Panel • 11kV RTU Panel (RTU 3, RTU4, or RTU5) • 11kV Bus Protection Panel • 11kV Metering Panel	11kV Capacitor Bank Bay	
11kV Bus Coupler Bay	Install an 11kV Bus Coupler Bay, including HV plant and equipment, and secondary systems • Based on I-Power 11kV Switchboard	Z2-32D Single Line Diagrams (or Z2-20D) Z6-32D Single Line Diagrams (or Z6-20D) Z7-32D Single Line Diagrams (or Z7-20D) 11kV Indoor Switchboard General Arrangement 11kV Indoor Switchboard Standard Earthing Use design modules for:- • 11kV Bus Protection Panel (Bus 1,Bus 2,or Bus 3) • 11kV RTU Panel (RTU4)	11kV Bus Coupler Bay	

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
PLANT AND EQUIPMENT				
66/11kV 32MVA Modular Switchgear Building	Install a 66/11kV 32MVA Modular Switchgear Building • Based on iPower Solutions switchboard consist of - 2 x transf incomer CB - 12 x feeder CB - 2 x cap bank CB - 2 x bus section CB - 1 x bus earth switch - 2 x bus riser / VT	Building Equipment Layout Building Plans and Sections Building Footing and Conduit Plan Cable Ladder Layout Light & Power Layout Fire & Communications Layout Earthing Layout Signage Layout Switchboard General Arrangement	Substation Modular Building and Indoor Equipment	
66/11kV 32MVA Modular Control Building	Install a 66/11kV 32MVA Modular Control Building, including Protection & Control Panels, Communications, AC & DC Systems, AFLC Transmitter	Building Equipment Layout Building Plans and Sections Building Footing and Conduit Plan Cable Ladder Layout Light & Power Layout Fire & Communications Layout Earthing Layout Signage Layout	Substation Modular Building and Indoor Equipment	
66/11kV Transformer 32MVA	Install a 66/11kV 32MVA transformer, including foundations, bund design, and oil containment • Based on Wilson Transformer Serial P1110D	Transformer General Arrangement Transformer foundation, bund, & oil containment 66kV Surge Arrester General Arrangement Power Transformer Standard Earthing	66/11kV 32MVA Transformer 66kV Transformer Bay	S_TXM2_INS S_66TFR32_OD

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
	• Excludes transformer protection panel • Excludes metering	Surge Arrester Standard Earthing Transformer AC Wiring Schematics Transformer Protection DC Wiring Schematics SCADA RTU ADI Card Connections SCADA RTU DO Card Connections Transformer Panel Connection Diagram Transformer Control Cubicle Connection Diagram Cable Schedules		
66/11kV Transformer 20MVA	Install a 66/11kV 20MVA transformer, including foundations, bund design, and oil containment	Use template drawings for 66/11kV Transformer 32MVA design module. Substitute & update drawings for 20MVA transformer		
66kV Outdoor Circuit Breaker	Install an outdoor live tank 66kV circuit breaker, including foundations, cabling and secondary systems • Based on Alstom GL309 Circuit Breaker • Excludes protection and control panel	Circuit Breaker General Arrangement Circuit Breaker foundation Circuit Breaker Standard Earthing Transformer CB Protection & Control DC Schematic Transformer Yard Equipment Connection Diagram Feeder CB Protection & Control DC Schematic Feeder Yard Equipment Connection Diagram SCADA RTU ADI Card Connections SCADA RTU DO Card Connections Cable Schedules	66kV Circuit Breaker Live Tank 66kV Feeder Bay 66kV Transformer Bay 66kV Bus Coupler Bay	S_66CB_INS S_66FDR_OD S_66TFR32_OD S_66BUS_OD
66kV Current Transformer	Install a 66kV current transformer, including support steelwork, foundations, cabling and secondary systems	CT General Arrangement Current Transformer Support Steelwork	66kV Current Transformer 66kV Feeder Bay	S_66CT_INS S_66FDR_OD

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
	• Based on Koncar 66kV Current Transformer	Current Transformer foundation CT Marshalling Box Details & Fabrication Current Transformer Standard Earthing Transformer AC Wiring Schematic Transformer Main Protection AC Wiring Schematic Transformer Backup Protection AC Wiring Schematic Transformer Yard Equipment Connection Diagram Feeder AC Wiring Schematic Feeder Yard Equipment Connection Diagram Cable Schedules	66kV Transformer Bay 66kV Bus Coupler Bay	S_66TFR32_OD S_66BUS_OD
66kV Voltage Transformer	Install a 66kV voltage transformer, including support steelwork, foundations, cabling and secondary systems • Based on Crompton Greaves Voltage Transformer	VT General Arrangement Voltage Transformer Support Steelwork Voltage Transformer foundation VT Marshalling Box Details & Fabrication Voltage Transformer Standard Earthing Feeder AC Wiring Schematic Feeder Yard Equipment Connection Diagram Cable Schedules	66kV Voltage Transformer 66kV Feeder Bay	S_66VT_INS S_66FDR_OD
66kV Disconnector	Install a 66kV disconnector, including foundations, cabling and secondary systems • Based on AK Power Disconnector	Disconnector General Arrangement Disconnector foundation Disconnector Standard Earthing Transformer Yard Equipment Connection Diagram Feeder Yard Equipment Connection Diagram	66kV Disconnector 66kV Feeder Bay 66kV Transformer Bay 66kV Bus Coupler Bay	S_66ISOL_INS S_66FDR_OD S_66TFR32_OD S_66BUS_OD

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
		SCADA RTU ADI Card Connections Cable Schedules		
66kV Surge Arrester (Feeder)	Install a 66kV surge arrester, including support steelwork and foundations	Surge Arrester General Arrangement Surge Arrester Support Steelwork Surge Arrester Standard Earthing	66kV Surge Arrester 66kV Feeder Bay	S_66FDR_OD
66kV Surge Arrester (Transformer)	Install a 66kV transformer surge arrester (mounted on transformer support bracket)	Surge Arrester General Arrangement Surge Arrester Standard Earthing	66kV Surge Arrester 66kV Transformer Bay	S_66TFR32_OD
11kV Capacitor Bank	Install an 11kV Capacitor Bank including foundation, cabling and secondary systems • Based on ABB two stage capacitor bank • Excludes capacitor protection panel • Excludes metering	Capacitor Bank General Arrangement Capacitor Bank foundation Capacitor Bank Standard Earthing Capacitor Bank AC Wiring Schematic Capacitor Bank CB Control Wiring Schematic Capacitor Bank Control & Indication Wiring Schematic Capacitor Bank Cubicle Connection Diagram Cable Schedules	11kV Capacitor Bank	S_11CAP_SUB
22kV Capacitor Bank	Install a 22kV Capacitor Bank including foundation, cabling and secondary systems • Based on ABB two stage capacitor bank • Excludes capacitor protection panel • Excludes metering	Use template drawings for 11kV Capacitor Bank design module. Substitute & update drawings for 22kV Capacitor Bank	22kV Capacitor Bank	S_22CAP_SUB

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
SECONDARY SYSTEMS				
66/11kV Transformer Protection Panel	Install a 66/11kV transformer protection panel with duplicate differential protection and interface to substation SCADA Based on: • SEL387A Differential Main Protection • Micom P642 Differential Backup Protection	Transformer Panel Layout Transformer Panel Equipment List Transformer AC Wiring Schematics Transformer Protection DC Wiring Schematics Transformer 66kV CB Control Wiring Schematic Transformer 11kV CB Control Wiring Schematic SCADA RTU ADI Card Connections SCADA RTU DO Card Connections Transformer Panel Connection Diagram Transformer Control Cubicle Connection Diagram Transformer 66kV Yard Equipment Connection Diagram Transformer 11kV Switchgear Connection Diagram Cable Schedules	66kV Transformer Panel 66kV Transformer Bay	S_66TFR32_OD
66kV Feeder Protection Panel – Current Diff	Install a 66kV feeder panel with duplicate differential protection and interface to substation SCADA Based on: • SEL311L Differential Main Protection • Micom P543 Differential Backup Protection	Feeder Panel Layout Feeder Panel Equipment List Feeder AC Wiring Schematic Feeder Protection DC Wiring Schematics Feeder 66kV CB Control Wiring Schematic SCADA RTU ADI Card Connections Feeder Panel Connection Diagram Feeder 66kV Yard Equipment Connection Diagram	66kV Feeder Bay	S_66FDR_OD

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
		Cable Schedules		
66kV Feeder Protection Panel – Distance	Install a 66kV feeder panel with duplicate distance protection and interface to substation SCADA Based on: • SEL311C Distance Main Protection • Micom P445 Distance Backup Protection	Feeder Panel Layout Feeder Panel Equipment List Feeder AC Wiring Schematic Feeder Protection DC Wiring Schematics Feeder 66kV CB Control Wiring Schematic SCADA RTU ADI Card Connections Feeder Panel Connection Diagram Feeder 66kV Yard Equipment Connection Diagram Cable Schedules	66kV Feeder Bay	S_66FDR_OD
66kV RTU 1 Panel	Install a 66kV RTU panel for SCADA control of feeder bays, transformer bay, and bus section bay	SCADA RTU Panel Layout SCADA RTU Panel Equipment List SCADA RTU ADI Card Connections SCADA RTU DO Card Connections SCADA RTU Panel Connection Diagram Cable Schedules	66kV RTU Panel 66kV Feeder Bay 66kV Transformer Bay 66kV Bus Coupler Bay	 S_66FDR_OD S_66TFR32_OD S_66BUS_OD
66kV RTU 2 Panel	Install a 66kV RTU panel for SCADA control of feeder bays, and transformer bay	SCADA RTU Panel Layout SCADA RTU Panel Equipment List SCADA RTU ADI Card Connections SCADA RTU DO Card Connections SCADA RTU Panel Connection Diagram Cable Schedules	66kV RTU Panel 66kV Feeder Bay 66kV Transformer Bay	 S_66FDR_OD S_66TFR32_OD
66kV Bus Zone 1 Protection	Install a 66kV bus protection panel, including Bus Section CB	Bus Zone Panel Layout	66kV Bus Panel	

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
Panel	control, and interface to substation SCADA Based on: • RMS 1M123 High Impedance Diff Main Protection • SEL351-6 Bus section CB Fail Main Protection • Areva MFAC34 High Impedance Diff Backup Protection • Micom P142 Bus section CB Fail Backup Protection	Bus Zone Panel Equipment List Bus Zone AC Wiring Schematics Bus Zone Protection DC Wiring Schematics Bus Section 66kV CB Control Wiring Schematic SCADA RTU ADI Card Connections Bus Zone Panel Connection Diagram Bus Section 66kV Yard Equipment Connection Diagram Cable Schedules	66kV Feeder Bay 66kV Transformer Bay 66kV Bus Coupler Bay	S_66FDR_OD S_66TFR32_OD S_66BUS_OD
66kV Bus Zone 2 Protection Panel	Install a 66kV bus protection panel and interface to substation SCADA Based on: • RMS 1M123 High Impedance Diff Main Protection • Areva MFAC34 High Impedance Diff Backup Protection	Bus Zone Panel Layout Bus Zone Panel Equipment List Bus Zone AC Wiring Schematics Bus Zone Protection DC Wiring Schematics Bus Zone Panel Connection Diagram Cable Schedules	66kV Bus Panel 66kV Feeder Bay 66kV Transformer Bay 66kV Bus Coupler Bay	 S_66FDR_OD S_66TFR32_OD S_66BUS_OD
11kV Feeder Protection Panel	Install an 11kV feeder panel and interface to substation SCADA Based on: • SEL351-6 Feeder Management Relay	Feeder Panel Layout Feeder Panel Equipment List Feeder AC Wiring Schematic Feeder Protection DC Wiring Schematic Feeder 11kV CB Control Wiring Schematic	11kV Feeder Bay	

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
		SCADA RTU ADI Card Connections Feeder Panel Connection Diagram Feeder 11kV Switchgear Connection Diagram Cable Schedules		
11kV Capacitor Bank Protection Panel	Install an 11kV capacitor bank panel and interface to substation SCADA Based on: • SEL351-6 Feeder Management Relay • ABB SPAJ160C Capacitor Relay	Capacitor Bank Panel Layout Capacitor Bank Panel Equipment List Capacitor Bank AC Wiring Schematic Capacitor Bank Protection DC Wiring Schematic Capacitor Bank 11kV CB Control Wiring Schematic Capacitor Bank Control & Indications Wiring Schematic Capacitor Bank Panel Connection Diagram Capacitor Bank 11kV Switchgear Connection Diagram Capacitor Bank Cubicle Connection Diagram Cable Schedules	11kV Capacitor Bank Bay	
11kV Bus Zone 1 Protection Panel	Install an 11kV bus protection panel, including Bus Section CB control, and interface to substation SCADA Based on: • RMS 1M123 High Impedance Diff Main Protection • SEL 351-6 Summated Overcurrent Backup Protection	Bus Zone Panel Layout Bus Zone Panel Equipment List Bus Zone AC Wiring Schematics Bus Zone Protection DC Wiring Schematics Bus Section 11kV CB Control Wiring Schematic SCADA RTU ADI Card Connections Bus Zone Panel Connection Diagram Bus Section 11kV Switchgear Connection Diagram	11kV Bus	

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
	• SEL351-6 Bus section CB Fail Protection	Cable Schedules		
11kV Bus Zone 2 Protection Panel	Install an 11kV bus protection panel, including SEF substation check, 11kV VT changeover, and interface to substation SCADA Based on: • RMS 1M123 High Impedance Diff Main Protection • SEL 351-6 Summated Overcurrent Backup Protection • Micom P120 SEF Check	Bus Zone Panel Layout Bus Zone Panel Equipment List Bus Zone AC Wiring Schematic Bus Zone Protection DC Wiring Schematics SEF Check Protection DC Wiring Schematic Bus Voltage Selection AC & DC Wiring Schematic Bus Zone Panel Connection Diagram Cable Schedules	11kV Bus	
11kV Bus Zone 3 Protection Panel	Install an 11kV bus protection panel, including Bus Section CB control, and interface to substation SCADA Based on: • RMS 1M123 High Impedance Diff Main Protection • SEL 351-6 Summated Overcurrent Backup Protection • SEL351-6 Bus section CB Fail Protection	Bus Zone Panel Layout Bus Zone Panel Equipment List Bus Zone AC Wiring Schematics Bus Zone Protection DC Wiring Schematics Bus Section 11kV CB Control Wiring Schematic SCADA RTU ADI Card Connections Bus Zone Panel Connection Diagram Bus Section 11kV Switchgear Connection Diagram Cable Schedules	11kV Bus	
Metering Panel 11kV	Install an 11kV metering panel	Metering Panel Layout	66kV Transformer Bay	S_66TFR32_OD

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Design Module	Description	Applicable Drawings and Templates for Design Module	Product/s	Standard Estimate
		Metering Panel Equipment List Metering Voltage Selection AC Wiring Schematic Metering AC Wiring Schematic Metering DC Wiring Schematic Metering Panel Connection Diagram Cable Schedules	11kV Capacitor Bay 11kV AFLC Bay AC System	
Metering Panel 66kV	Install a 66kV metering panel	Metering Panel Layout Metering Panel Equipment List Metering AC Wiring Schematic Metering DC Wiring Schematic Metering Panel Connection Diagram Cable Schedules	66kV Feeder Bay 66kV AFLC Bay	S_66FDR_OD
Metering Panel – Revenue	Install an 11kV revenue metering panel	Metering Panel Layout Metering Panel Equipment List Metering AC Wiring Schematic Metering DC Wiring Schematic Metering Panel Connection Diagram Cable Schedules	11kV Feeder Bay	

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ANNEX J – SUBSTATION DRAWING LIST

The following table lists the drawings typically required for a substation. The required quantity of each drawing type, any additional drawings and drawing sheets required for a specific project must be determined by the designer, and in accordance with the ZSS template drawings.

Electrical Drawings	Drawing
Single Line Diagrams	Single Line Diagram Plant
	Single Line Diagram Operating
	Single Line Diagram Protection and Metering
	Single Line Diagram Communications and SCADA
	Single Line Diagram Revenue Metering
Switchyard Layout	General Arrangement Plan
	General Arrangement Ultimate Plan
	General Arrangement Elevations
	Earth Grid Layout
Equipment	Material List Major Plant HV
	Material List Major Plant LV
	Material List Structures and Poles
	Material List Busbar, Conductors and Fittings
	Material List Miscellaneous
	Material List Buildings
	Material List Earthing
DC Systems	DC Supply System Single Line Diagram
	DC Supply System DC Wiring Schematic
	DC Supply System DC Distribution Board Wiring Schematic
AC Systems	AC Distribution Supply Single Line Diagram
	AC Distribution Supply Main Switchboard General Arrangement
	AC Distribution Supply Wiring Schematic
	AC Distribution Supply Essential Supplies Board Wiring Schematic
	AC Distribution Supply Non-Essential Supplies Board Wiring Schematic
	AC Distribution Supply Essential Supplies Sub-Board Wiring Schematic and Layout
	AC Distribution Supply Non-Essential Supplies Sub-Board Wiring Schematic and Layout
Transmission / Sub-Transmission Feeder	Feeder Panel Equipment Layout
	Feeder Panel Equipment Identification
	Feeder AC Wiring Schematic
	Feeder CB Protection & Control DC Wiring Schematic

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	Feeder Main Protection DC Wiring Schematic
	Feeder Backup Protection DC Wiring Schematic
	Feeder Panel Connection Diagram
	Feeder Yard Equipment Connection Diagram
Distribution Feeder	Feeder Panel Equipment Layout
	Feeder Panel Equipment Identification
	Feeder AC Wiring Schematic
	Feeder CB Protection & Control DC Wiring Schematic
	Feeder Protection DC Wiring Schematic
	Feeder Panel Connection Diagram
	Feeder Switchgear Panel Connection Diagram
Transformer	Transformer Panel Equipment Layout
	Transformer Panel Equipment Identification
	Transformer 66kV AC Wiring Schematic
	Transformer 11kV AC Wiring Schematic
	Transformer Main Protection AC Wiring Schematic
	Transformer Backup Protection AC Wiring Schematic
	Transformer 66kV CB Protection & Control DC Wiring Schematic
	Transformer 11kV CB Protection & Control DC Wiring Schematic
	Transformer Main Protection DC Wiring Schematic
	Transformer Backup Protection DC Wiring Schematic
	Transformer Inputs To RTU DC Wiring Schematic
	Transformer Panel Connection Diagram
	Transformer Control Cubicle Connection Diagram
	Transformer Yard Equipment Connection Diagram
	Transformer Switchgear Panel Connection Diagram
Bus Protection	Bus Zone & Bus Section CB Panel Equipment Layout
	Bus Zone & Bus Section CB Panel Equipment Identification
	Bus Section AC Wiring Schematic
	Bus Zone & Bus Section CB Main Protection AC Wiring Schematic
	Bus Zone & Bus Section CB Backup Protection AC Wiring Schematic
	Bus Section CB Protection & Control DC Wiring Schematic
	Bus Zone Main Protection DC Wiring Schematic
	Bus Section Main CB Fail Protection DC Wiring Schematic
	Bus Zone Backup Protection DC Wiring Schematic

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	Bus Section Backup CB Fail Protection DC Wiring Schematic
	Bus Zone Panel Connection Diagram
	Bus Section Yard Equipment Connection Diagram
Switchboard Bus Protection	Bus Zone & Bus Section Panel Equipment Layout
	Bus Zone & Bus Section Panel Equipment Identification
	Bus Zone & Bus Section Main Protection - AC Wiring Schematic
	Bus Zone & Bus Section Backup Protection - AC Wiring Schematic
	Bus Section CB Protection & Control - Wiring Schematic
	Bus Zone Main Protection DC Wiring Schematic
	Bus Zone Backup Protection DC Wiring Schematic
	Bus Zone CB Fail Protection DC Wiring Schematic
	Bus Zone & Bus Section Panel Connection Diagram
	Bus Section Switchgear Panels Connection Diagram
SEF Check and Switchboard Bus Volts	SEF Check Protection DC Wiring Schematic
	Bus Volts Selection AC & DC Wiring Schematic
	Bus Zone & SEF Check Protection & Volts Selection Panel Connection Diagram
Metering Panel	Statistical Metering Panel Equipment Layout
	Statistical Metering Panel Equipment Identification
	Statistical Metering Panel Voltage Selection AC Wiring Schematic
	Statistical Metering Panel AC Wiring Schematic
	Statistical Metering Panel DC Wiring Schematic
	Statistical Metering Panel Connection Diagram
SCADA RTU	SCADA RTU Panel Equipment Layout
	SCADA RTU Panel Equipment Identification
	SCADA RTU Panel Power Supply, Cope Card & 8ch Serial Card Connections
	SCADA RTU Panel ADI Card Connections
	SCADA RTU Panel DO Cards Connections
	SCADA RTU Panel Cable Connection Diagram
	RTU Optonet Connections
Cable Schedules	Cables -Wxxx To -Wxxx Cable Schedule
Marshalling Box	CT Marshalling Box Fabrication Detail
	CT Marshalling Box Fitout
	VT Marshalling Box Fabrication Detail
	VT Marshalling Box Fitout

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Civil Drawings	Drawing
Layout	Site Layout
	Site Contour Plan
	Site Survey Plan
	Site Roadworks & Earthworks Cross Sections and Details
	General Arrangement Foundations
	General Arrangement Ground Services Plan
Building	Building - Architectural
	Building - Electrical Services
	Building - Mechanical Services
	Building - Fire & Security Services
	Building - Equipment Layout
	Building - Cable Tray
	Building - Conduit Layout
	Building - Earthing
Structures	Earthing Transformer Cable Support
	Surge Arrestor Support
	Current Transformer Support
	Surge Arrestor and Cable Pothead Support
	Low Bus and Post Insulator Support
	Capacitor Voltage Transformer Support
	High Bus and Post Insulator Support
	Incoming Termination Strung Bus Support Concrete Pole
	Termination Strung Bus Support
	Lightning Mast

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Footings	Current Transformer Support
	Surge Arrestor & Cable Pothead Support
	Surge Arrestor Support
	Disconnector/Earth Switch Support
	Capacitor Voltage Transformer Support
	Circuit Breaker Support
	High Bus And Post Insulator Support
	Lightning Mast Structure
	Lighting Pole
	Capacitor Bank
	Cable Duct Plan, Sections and Details

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